DOCUMENT RESUME

ED 091 169 SE 017 386

| | |
|---|---|
| TITLE | National Assessment Findings in Science 1969-70, What Do They Mean? |
| INSTITUTION | National Science Teachers Association, Washington, D.C. |
| PUB DATE | 73 |
| NOTE | 69p. |
| AVAILABLE FROM | National Science Teachers Association, 1201 16th Street, N.W., Washington, D.C. 20036 (Stock No. 471-14656, $5.00) |
| EDRS PRICE | MF-$0.75 HC-$3.15 PLUS POSTAGE |
| DESCRIPTORS | *Achievement; *Cognitive Measurement; Educational Research; Elementary School Students; *Evaluation; Junior High School Students; *National Surveys; *Science Education; Secondary School Students; Young Adults |
| IDENTIFIERS | NAEP; *National Assessment of Educational Progress |

ABSTRACT

This booklet contains a discussion of the 1969-70 findings in science of the National Assessment of Educational Progress (NAEP). Four age levels of the population: 9, 13, 17, and young adult (25-35) were sampled. This publication contains a preface in which Robert H. Carleton reacts to NAEP and presents the NSTA's perspective of the project, a general introduction, a section on the goals and methods of NAEP, a section which contains a report of the findings of the first assessment, and a final section entitled "Judgments and Concluding Statements." Also included in the publication are five appendixes: Profiles of Study Team Members; Changes in Assessment Procedures 1972-73; Interrelationships Between Findings in National Assessment of Science, Reading, and Citizenship; Bibliography with Selected Annotations; and Released Items from the 1969-70 Science Assessment. (PEB)

U.S. DEPARTMENT OF HEALTH
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

# NATIONAL ASSESSMENT

# FINDINGS IN SCIENCE 1969-70

# WHAT DO THEY MEAN?

SE 017 396

National Science Teachers Association
Washington, D.C. 1973

ED091169

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# ACKNOWLEDGMENTS

Our study team acknowledges with a profound sense of gratitude the help it received from Carol Byerly and Robert C. Larson of the NAEP office in Denver. NSTA was the first professional organization to examine the NAEP findings for implications for teachers and teaching. As we worked to find procedures and to orient ourselves to our task Ms. Byerly and Mr. Larson were able to help us in many important ways. The production of the final report was also facilitated by the diligent work of Carolyn Chia, Clarissa Crissman, and Shirley Lovenguth. In addition, the study team received wise advice and strong support from Robert H. Carleton, NSTA executive secretary. As is customary, the members of the team accept full responsibility for any errors of judgment found in this report.

James D. Ratliff
Chairman

# PREFACE

## NSTA PERSPECTIVE ON NAEP

"How well are we doing in education?" has long been a question of deep concern to many segments of the American public, probably ever since the days of the founding fathers. In terms of a carefully designed plan for continuing efforts to get some answers, however, an action peak was reached in 1966 when the work of the National Assessment of Educational Progress (NAEP) was started with initial funding by the United States Office of Education, the Fund for the Advancement of Education of the Ford Foundation, and the Carnegie Corporation. Briefly stated, NAEP was to be, and is, an effort to provide our country with reliable data about the educational attainments of young Americans, *en mass*, in curriculum areas, one of them being science. The basic plan provides for science assessment at four age levels of the population: age 9, age 13, age 17, and young adult (ages 26-35). But no individual pupil, no single school, no total school system is fully tested and scored by NAEP. The approach is based on a sampling technique by which data are collected according to precise statistical design and are then assembled to reveal composite wholes as desired. This procedure is somewhat analogous to sticking a thermometer into a bathtub of water to get a reading of average kinetic energy of the molecules or to gathering data from which to estimate our "gross national product in education" (GNPE).

The National Science Teachers Association (NSTA) has been a supporter of NAEP from its beginning. Although several educational groups initially opposed or took a dim view of the proposed project and termed it a threat or first step toward imposition of a national curriculum, the NSTA board of directors took prompt action, perhaps the first among our kind of organization, to endorse the concept of NAEP and to encourage science teachers to support and participate in the endeavor (see *The Science Teacher*, November 1968, p. 44). Since then, the Association has been involved in every stage of the NAEP assessment in science. Through the participation of designated representatives, NSTA has shared in defining the objectives of the assessment in reviewing the exercises (the questions and test items) to be used in assessment, and in reviewing, reacting to, and disseminating findings. We accepted gladly many additional opportunities to provide information, offer counsel, and suggest personnel to NAEP staff.

The latest NSTA involvement with NAEP has resulted in the report given in the following pages. It came about this way. The first round assessment in science took place during academic year 1969-'70. Preliminary reports of findings were released in mid-summer 1970 at a press conference at which NSTA representatives Richard J. Merrill (Mt. Diablo Unified School District, Concord, California), Mildred Ballou (Ball State University, Muncie, Indiana), and Wilmer Cooksey (Woodrow Wilson High School, Washington, D.C.) provided reactions and comments and raised questions. Subsequent reports of science findings in more detail were released over the ensuing 18 months by NAEP, which had earlier been transferred from being an essentially independent project housed in Ann Arbor, Michigan, to becoming a project of the Education Commission of the States (ECS) located in Denver, Colorado. By early 1972, word was getting around that NAEP was about to ask a group of scientists, business leaders, and a few others (including no mention of science teachers) to undertake a study of the findings and seek out their "meanings." At this approach point, NSTA President Morris R. Lerner wrote to NAEP to suggest that NSTA should do such a study (see *The Science Teacher*, May 1972, p. 76). Perhaps it should be said that NAEP staff have conscientiously refrained from interpreting the data collected, suggesting implications, or making recommendations because their commission is simply to provide the data; the search for reality among the data is a task for others who are interested in the GNPE.

The Lerner suggestion ignited immediate interest on the part of NAEP. Within six weeks NSTA had submitted a detailed proposal which was accepted by the Education Commission of the States and was approved by the United States Office of Education (which is now the sole funding agency for NAEP, about $6 million per year). An 11-member study team was named. This group was deemed representative of diverse geographical areas of the United States, different levels and aspects of science instruction from elementary school to the university, and several different science disciplines, as follows: R. Julian Brandon, Michigan State University; Wilmer Cooksey, Woodrow Wilson High School, Washington, D.C.; Fred Johnson, Shelby County (Tennessee) Board of Education; G. Richard Kay, Idaho State Department of Education; Morris R. Lerner, Barringer High School, Newark, New Jersey; Richard J. Merrill, Mt. Diablo Unified School District, Concord, California; Joseph Struthers, Boulder Valley (Colorado) Elementary School; Leslie Trowbridge, University of Northern Colorado; James E. Wailes, University of Colorado; Charles Wilson, New Dorp High School, Staten Island, New York; and *chairman* James D. Raths, Univer-

sity of Illinois at Urbana-Champaign. (At the time of appointment, Dr. Raths was chairman of the Bureau of Field Services and Educational Research, University of Maryland).

Three of the team members were Black. The absence of females is explained by the fact that three days before the first scheduled meeting of the original team, circumstances beyond control necessitated sudden changes in scheduling and caused the dropout of five original team members, including all three females who previously had agreed to serve.

The team held four-day work conferences at Colorado State University, Fort Collins, in September and at St. Mary's Dominican College in New Orleans, in November. Prior to, in between, and following these conferences all team members had heavy homework assignments. This report, expresses their views of what they found and what they think about it. On behalf of the NSTA board of directors, I extend deep, sincere thanks and appreciation to USOE, ECS, and NAEP for their confidence and support making this study possible, and likewise to all the team members, and to chairman Raths in particular, for their hard work and contributions in getting the job done.

In conclusion, I can not refrain from editorial comment. I am confident that the team's study takes us about as far as possible from present data toward reality. Whatever shortcomings the 1969-70 science assessment may have had, we should identify them only because we desire and visualize something better. Round one science assessment has given us a bank of data heretofore nonexistent; some benchmarks, however indistinct, have been established. Round two assessment, now under way 1972-73, should add refinements and result in some fairly reliable bases for checking gains (or losses) in science achievement as future assessments occur at five-year intervals. A big, plus value from NAEP can be stimulating all of us to consider more seriously what *our* objectives are, what goals and intentions we are working on with *all* of *our* students; in short, why *science* in *our* schools? Moreover, we can expect and should prepare for more NAEP-like assessments, possibly as a component of the general movement toward "accountability." At the time of this writing, reports are that at least 16 states and several school systems have asked for and are receiving help from NAEP in devising their own independent assessment programs. It would behoove all science teachers—elementary, secondary, and college—and their state or special area organizations to find out about these programs, to become involved, and to seek to exert maximum influence toward the kind of science education best suited to our times.

Robert H. Carleton
Executive Secretary

# NATIONAL ASSESSMENT FINDINGS IN SCIENCE 1969-1970

# WHAT DO THEY MEAN?[1]

## INTRODUCTION

"Not just data—but reality" reads an advertising slogan for a distinguished computer firm. The work of the National Assessment of Educational Progress appears to be an effort to provide the citizens of this country with data about the educational attainments of young Americans. Unlike the computer firm cited above, however, the NAEP leadership has conscientiously refrained from interpreting the data it has collected. The determination of reality is by design a task for others. In the early summer of 1972, the National Science Teachers Association, under the leadership of President Morris R. Lerner and Executive Secretary Robert H. Carleton, appointed the study team to examine the findings from the first NAEP science assessment.[2] The team was to answer the broad question: "What do the results of the science assessment mean?"

In the early fall of 1972, the group met in Fort Collins, Colorado, with members of the NAEP staff to clarify some perceptions about the purposes of the assessment effort and some problems associated with the interpretation of the statistical analyses found in the NAEP reports. The group charted ways the data could be re-analyzed, what new data breakouts might enhance a study of the findings, and how the study team itself could best proceed. Individual members accepted specific writing assignments to advance the work of the team. In addition, every member of the group identified sources to include in the bibliography that is a part of this report (Appendix IV). At a second meeting in New Orleans in November, study team members shared the manuscripts which they had prepared on various aspects of the NAEP findings. The initial drafts were critiqued and reviewed by the entire team, and revisions were suggested. Also at this meeting various drafts of recommendations were studied by team members and suggestions for revisions were entertained. A draft of the report was circulated to all the members of the study team by mail and also to NAEP officials in Denver, who provided additional data and valuable suggestions. This final report summarizes by and large the thinking and feelings of all members of the study team.

Several limitations influenced the scope of this report. First, for the most part, the study team worked with data associated with those items that were released to the public by NAEP. Over half of the items were held back for use in subsequent testing cycles. Second, it was impossible for the study team to assess with any precision matters of sampling, of measurement, or of data analysis. In the first place, the study team was not staffed with sophisticated statistical experts nor with authorities in probability sampling; additionally, the study team felt that any efforts to focus on methodological issues might detract from the central focus of its charge—namely, *to interpret the findings* of the science assessment as reported by NAEP. As a final limitation, while conceding that the findings of the science assessment may have great import for industry, for government, and for others, our study team limited its concerns to issues of *science teaching*.

This report is organized into three central sections. The first deals with brief descriptions of the procedures used by NAEP to prepare the instruments, to sample the appropriate populations, and to analyze the data. Next, the salient findings of the science assessment, 1969-70, are summarized under various headings quite similar to those used in the NAEP publications. Finally, interpretations of the findings, some concluding statements, and some recommendations close the report. Appended materials include a bibliography with selected annotations, a complete list of the released items, profiles of study team members, and a comment on the apparent interrelationships between the findings in NAEP assessments in science, reading, and citizenship.

[1] The views expressed in this report do not necessarily represent the positions of the National Science Teachers Association, the United States Office of Education, or of the National Assessment of Educational Progress.

[2] Biographical sketches of the study team members appear in Appendix I.

# GOALS AND METHODS OF NAEP

The National Assessment of Educational Progress was organized to carry out a census-like survey of knowledge, skills, understandings, and attitudes of young Americans. Its two major goals are:

1. To make available the first comprehensive data on the educational attainments of young Americans.

2. To measure any growth or decline which takes place in selected aspects of the educational attainments of young Americans in certain subject areas. [1]

Ten subject areas are being assessed and re-assessed; namely, citizenship, science, writing, music, mathematics, literature, social studies, reading, art, and career and occupational development. The assessments are being carried out according to the following schedule. [2]

*Cycle 1*

| | |
|---|---|
| March 1969—February 1970 | Science, Writing, Citizenship |
| October 1970—August 1971 | Reading, Literature |
| October 1971—August 1972 | Music, Social Studies |
| October 1972—August 1973 | Math, Science |
| October 1973—August 1974 | Writing**, Career and Occupational Development |
| October 1974—August 1975 | Citizenship**, Art |

*Cycle 2*

| | |
|---|---|
| October 1975—August 1976 | Reading**, Literature** |
| October 1976—August 1977 | Music*, Social Studies* |
| October 1977—August 1978 | Math*, Science*** |
| October 1978—August 1979 | Career and Occupational Development**, Writing*** |
| October 1979—August 1980 | Citizenship***, Art** |

*No explanation
**Second cycle
***Third cycle

By gathering information on a national scale about the "output" of education in the United States, NAEP hopes to assist those who are responsible for planning, implementing, and evaluating the educational programs of our society. Science was the first area to be re-assessed, and the results of the second effort will be available sometime during the early part of 1974. This report deals with the data collected during the first (1969-70) assessment.

### Selection of a Sample

The assessees were selected according to a nation-wide probability sampling plan that is described in detail in the NAEP literature. [3] After implementing the plan, a sample was defined which included about 28,000 individuals in each of the three younger groups and about 10,000 young adults for a total of more than 90,000 individuals. More than 2,500 schools participated in the first assessment by allowing project staff to administer exercises to the student sample. For out-of-school 17-years-olds and adults, dwelling units rather than schools had to be identified. In the last two assessments, approximately 95 percent of the eligible schools and 82 percent of the selected eligible adults have taken part. [4] In order to increase the number of adults cooperating, NAEP is paying adults and out-of-school 17-year-olds for cooperating with the project. (See Appendix II of this report.)

### Development of Objectives

The major criteria established by NAEP for objectives on which exercises were to be written were that (a) they be considered important by scholars in the field; (b) they be accepted as educational tasks by schools; and (c) they be considered desirable by thoughtful lay citizens. [5] Educational Testing Service of Princeton, New Jersey, drafted tentative statements of objectives and most of the items used in the first science assessment. The suggested objectives were reviewed and revised by a committee of prominent scientists and science teachers and science educators (named by NSTA) and later endorsed by several independent panels of lay persons from different regions of the United States. The procedures utilized to specify the objectives in science are described in greater detail in the NAEP publication *Science Objectives*. [6] (Changes have been made in the objectives for the 1972-73 assessment. These changes are described briefly in Appendix II.) The science objectives for 1969-70 with illustrative content categories are listed here.

OBJECTIVE I: Know the fundamental facts and principles of science

The facts and principles included:

A. Charge, momentum, mass-energy, and the conservation of these

B. Characteristics of electricity and magnetism

C. Characteristics of electromagnetic radiation

D. Atomic and molecular nature of matter

E. Discontinuities of matter

F. Classical mechanics (statics, dynamics, mechanics of continuous media)

G. Heat and simple kinetic theory

H. Nature (and control) of chemical reactions

I. Relation of structure of matter to behavior

J. Common types of chemical behavior (acids-bases, oxidation-reduction, elastomers and polymers)
K. Minerals and rocks
L. Erosion and weathering
M. Landforms
N. Fossils and geological history
O. Internal constitution of the earth
P. Diversity of living things
Q. Organization of living matter
R. Metabolism
S. Behavior of organisms
T. Reproduction
U. Evolution
V. Ecology
W. Elements of atmospheric science
X. Solar system—its arrangement and dynamics
Y. Stars and galaxies
Z. Ages and dimensions of the universe—sense of scale
AA. Health and nutrition
AB. Nature and properties of matter
BB. Laboratory observations and techniques in chemistry

OBJECTIVE II: Possess the abilities and skills needed to engage in the processes of science

The following abilities and skills were included:

A. Ability to identify and define a scientific problem

B. Ability to suggest or recognize a scientific hypothesis

C. Ability to propose or select validating procedures (both logical and empirical)

D. Ability to obtain requisite data

E. Ability to interpret data; i.e., to comprehend the meaning of data and recognize, formulate, and evaluate conclusions and generalizations on the basis of information known or given

F. Ability to check the logical consistency of hypotheses with relevant laws, facts, observations, or experiments

G. Ability to reason quantitatively and symbolically

H. Ability to distinguish among fact, hypothesis, and opinion; the relevant from the irrelevant; the model from the observations which the model was derived to describe

I. Ability to read scientific materials critically

J. Ability to employ scientific principles and laws in familiar or unfamiliar situations

OBJECTIVE III: Understand the investigative nature of science

The following concepts were included in this objective:

A. Scientific knowledge develops from observations and experiments and the interpretation of the observations and the experimental results; such observations and experiments are subject to critical examination and to repetition.

B. Observations are generalized in laws.

C. Laws are generalized in terms of theories.

D. Some questions are amenable to scientific inquiry, and others are not.

E. Measurement is an important feature of science because both the formulation and the establishment of laws are facilitated through the development of quantitative distinctions. Measurements are inherently and only approximate and are progressively inclusive and precise.

F. Science is not, and will probably never be, a finished enterprise.

OBJECTIVE IV: Have attitudes about and appreciation of scientists, science, and the consequences of science that stem from adequate understandings

The assessees should:

A. Recognize the distinction between science and its applications

B. Have accurate attitudes about scientists

C. Understand the relationship between science and misconceptions or superstitions

D. Be ready and willing knowingly to apply and utilize basic scientific principles and approaches, where appropriate, in everyday living

E. Be independently curious about and participate in scientific activities

To further delineate the objectives, descriptions of behaviors typical of each age were set down for many of the subobjectives (content areas). The delineations were written in terms of what approximately half of the individuals at a given age level might be expected to know or to do. For example, under the topic of Evolution listed for Objective I, the following delineations were constructed as indicating what individuals should know.

AGE 9 They should know that the earth is old and that many types of animals that once lived on this earth have become extinct.

AGE 13 They should know that there are systematic ways to classify plants and animals based on their complexity. They should have some knowledge of the fossil record and its part in the formation of the ideas of evolution.

AGE 17 These students should be familiar with the neo-Darwinian theory of organic evolution. They should know something about the relationship of mutation, sexual reproduction, and natural barriers to the evolutionary process.

ADULT They should know that man has been able to manipulate and cause some of the evolutionary changes that have been beneficial to man, especially in the area of agriculture.

Another example of attempts to elaborate upon the meanings of objectives by describing behaviors is found under Objective IV for the topic "observations are generalized in laws."

AGE 9 They should begin to realize that order can be observed in the universe.

AGE 13 They should know that laws are based on similar results having been observed repeatedly by many scientists working independently.

AGE 17 These students should realize that the generalization of observations into laws makes possible the predictions of the results of many experiments. They should understand the role of laws in the process of science.

ADULT They should appreciate the distinction between observations and laws. They should know that laws are generalizations about phenomena.

### Critique of the Objectives

The 29 illustrative content categories listed under Objective I appear to account quite adequately for any content that is likely to be dealt with in science in grades K-12. No major omissions are evident, and none of the categories seems inappropriate. However, it is difficult to surmise how these general objectives and subobjectives could possibly discipline an item writer in his work. Almost any question on any content in science could be justified under Objective I.

Objectives II and III represent a laudable attempt to recognize objectives related to rational thinking, science processes, and the nature of the scientific enterprise. There is evidently some redundancy in the set. Objective II-A seems quite similar to III-D; and II-B, -C, -D, and -E appear to overlap III-A. At least two important process objectives —the development of classification systems and the communication of scientific information—were overlooked or at least not addressed directly. (Note: The redundancy was apparently recognized by NAEP, for the objectives were restated before the second assessment cycle was implemented. The new objectives include: I. Know the fundamental aspects of science. II. Understand and apply the fundamental aspects of science in a wide range of problem situations. III. Appreciate the knowledge and processes of science, the consequences and limitations of science, and the personal and social relevance of science and technology in our society.)

In articulating objectives related to attitudes and appreciations, NAEP did recognize that there should be objectives in these areas. Very little else can be said of their effort. The writer of attitudinal objectives is faced with a dilemma. Forthright definitions of specific "desirable" attitudes or of behaviors that serve as indicators of such attitudes are usually controversial. They would not pass through the kind of screening utilized by the NAEP to select objectives. If, on the other hand, an attitude is considered acceptable if the person expressing it is well informed, then all that needs to be done is to measure information. The conflict is evident in the Objective IV statements. There are some of each approach there, and "have accurate attitudes about scientists" straddles the issue. Objectives IV-D and -E come closest to the mark. On the whole, the objectives upon which the science exercises were based are valid, reasonably comprehensive, and deserving of careful attention. Again, it must be noted that they have been rewritten and reorganized for the 1972-73 assessment.

### Constructing the Exercises

After the objectives had been defined and screened, agreements were reached to discipline the item writers. The following conditions were to be met by each exercise: [7]

1. The item is to sample some important knowledge, skill, or attitude.

2. The item should be written in whatever form or mode is most appropriate for the assessment of a particular objective.

3. The collection of items should call for knowledge and skills of varying difficulty—some which almost everyone has acquired, some which only about half have acquired, and some which only the most able are expected to have mastered.

In writing the items, a great deal of emphasis was placed on the "face" validity of each exercise. Since items were to be reported individually (results were not to be clustered, summed, or pooled), each item had to stand by itself and had to belong clearly to the area of knowledge, skill, or attitude with which it is identified. Of the many exercises that were generated, many were not found acceptable by subject-matter experts and by lay people. Some were judged to be offensive and others not pertinent to the objectives. [8]

*Distribution by objective.* The distribution of items by objective areas used in the first assessment is shown in Table 1 as reported by NAEP.

Table 1. Numbers of Exercises by Age Level and by Objective for the 1960-70 Science Assessment

| | Objectives | | | |
|---|---|---|---|---|
| Age Level | I | II | III | IV |
| Nine | 96 | 29 | 11 | 9 |
| Thirteen | 75 | 31 | 8 | 8 |
| Seventeen | 89 | 24 | 6 | 5 |
| Adult | 85 | 24 | 5 | 5 |
| Total | 345 | 108 | 30 | 27 |
| Percentage of total | 68% | 21% | 6% | 6% |

*Distribution by content area.* Within Objective I, the 29 content areas were not equally covered, at least as evidenced by the released items. (Approximately 60 percent of the exercises were not released so that they might be used in subsequent assessments.) Some content areas appear to be emphasized much more than are others, and there are differences in emphasis between age groups. The study team attempted to classify the released items into a condensed number of categories for purposes of depicting the distribution of exercises across content.

It is important in interpreting this array to recognize that the released items were not meant to be representative in a statistical sense of all the items in the assessment. They were selected to represent typical exercises in each objective and typical kinds of responses of subgroups within the total populations involved in the 1969-70 cycle. For instance, if girls did atypically well on one exercise at age 13, it might well have been selected for release for that reason. Nevertheless, the study team felt the information would be important to anyone making judgments about the significance of the NAEP project. The classifications are found in Table 2.

Major emphases at age 9 were in the areas of chemistry, energy-mechanics-kinetics, health and body functions, and plants. The least-emphasized areas for 9-year-olds were evolution, genetics, and electricity. For 13-year-olds, items dealing with physics and health and body functions seemed to be given heavy stress. Three or fewer released items dealt with each of the following: ecology, weather, earth science,

Table 2. Distribution of Released Exercises by Content Areas and Age Levels

| Content Areas (Objective I) | Age Level 9 | 13 | 17 | Adult | Total |
|---|---|---|---|---|---|
| Health and body functions (T,AA) | 5 | 7 | 5 | 11 | 28 |
| Plants (P,Q) | 5 | 1 | 1 | 2 | 9 |
| Animals (P,Q,R,S) | 4 | 2 | 2 | 2 | 10 |
| Ecology (V) | 1 | 1 | 3 | 3 | 8 |
| Evolution and genetics (U,Z) | 0 | 2 | 2 | 1 | 5 |
| Subtotal for biological sciences | 15 | 13 | 13 | 19 | 60 |
| Weather (W) | 3 | 3 | 1 | 2 | 9 |
| Earth's crust (K,L,M,N,O) | 4 | 3 | 4 | 5 | 16 |
| Astronomy (X,Y) | 3 | 0 | 1 | 0 | 4 |
| Chemistry, structure of matter (D,E,H,I,J,AB,BB) | 10 | 3 | 8 | 3 | 24 |
| Energy, mechanics, kinetics (A,C,F,G) | 5 | 10 | 12 | 8 | 35 |
| Electricity (A,B) | 1 | 0 | 4 | 2 | 7 |
| Subtotal for physical sciences | 26 | 9 | 30 | 20 | 95 |
| Objectives II, III, and IV | 15 | 12 | 7 | 8 | 42 |
| Content items not included above because considered seriously deficient by committee | 2 | 3 | 4 | 2 | 11 |
| Totals | 58 | 47 | 54 | 49 | 208 |

plants, animals, structure of matter, and evolution. No questions were released that touched the topics of astronomy or electricity.

The 17-year-olds were offered a distribution of items very similar to those offered to the 13-year-olds with at least one question in every category. For the adults, a decidedly different distribution of items was observed: Many more were in the categories of health and body functions although physics was given the second greatest stress.

*Distribution by difficulty.* As stated above, it was the policy of NAEP in selecting items for inclusion in the 1969-70 assessment to have, within each age group, a distribution of difficulties with some easy items, some hard items, and some of middling difficulty. Classifying the results of the assessment by the percentage in the nation getting the item correct indicates that the objective of the NAEP was reasonably well met. (See Table 3.) There was evidently a higher percentage of "easier" items in the 9-year-old collection than for any other age level. In addition, the items given to the 17-year-olds were evidently more difficult than those for other age levels.

To assess the distribution of difficulty by observing the number of subjects receiving credit for an item has a degree of circularity to it. An item is "easy," no matter how complex it might be, if many people get it right. Another way of viewing the difficulty of an item is in terms of the judgments of practitioners. Taking on that role, members of the study team acting in subcommittees rated each of the released exercises according to whether they felt that (a) almost all, (b) about half, or (c) very few of the persons at the age level(s) at which it was administered should be expected to respond correctly. The ratings were prejudiced by the fact that most of the team members had already perused the results of the assessment prior to making the ratings. There was very little agreement among the team members—but for the purposes of this analysis, central tendencies of judgments (the modal class) were noted. (See Table 4.) These data again support the observation that within each age level there were items of varying degrees of difficulty.

Table 3. Distribution of All Exercises Across Three Levels of Difficulty Defined by National Percentages Correct at Each Age Level

| Age Level | Easy Items (75-100% Correct) | Moderately Difficult (50-75% Correct) | Difficult (0-49% Correct) |
|---|---|---|---|
| Nine | 55 | 47 | 43 |
| Thirteen | 33 | 42 | 47 |
| Seventeen | 18 | 44 | 62 |
| Adult | 26 | 36 | 57 |
| Total | 132 | 159 | 209 |

Table 4. Distribution of Released Exercises Across Three Levels of Difficulty Defined by Study Team Member Judgments at Each Age Level

| Age Level | Almost All Should Respond Correctly | About Half Should Respond Correctly | Very Few Should Respond Correctly |
|---|---|---|---|
| Nine | 21 | 29 | 8 |
| Thirteen | 19 | 24 | 4 |
| Seventeen | 24 | 21 | 9 |
| Adult | 20 | 20 | 9 |
| Total | 84 | 94 | 30 |

## Critique of the Exercises

In general, the released exercises seem to be reasonably clear, concise, and related to the objectives they purport to measure. NAEP may be properly faulted for overreliance on multiple-choice questions. Some of these items are subject to criticisms to which most multiple-choice questions are vulnerable. During the course of its study, the team found what it considered to be significant, though not necessarily lethal, technical inadequacies in perhaps 25 or 30 of the items. Ambiguous items, debatable "correct" answers, trivial or tricky distractors are there to be found, but not in overwhelming numbers. (Brief criticisms of specific items were given to NAEP.)

The emphasis given by calling the items "exercises" as though they were in a category separate from ordinary test items is a bit misleading since only 8% of all the items fell outside of the multiple-choice category. (Increased emphasis has been given to other forms than multiple choice in the second assessment cycle. See Appendix J.) Nevertheless, the inclusion in an assessment of this magnitude of even relatively small numbers of exercises requiring manipulation of apparatus or free responses to questions is a notable achievement. The NAEP makes no claim about the validity of its data other than citing the processes for defining objectives and writing items as being ones which should generate a collection with considerable face validity. Science teachers may judge this matter for themselves in part by examining the released items included in Appendix V of this report.

A serious criticism of the assessment stems from the fact that more than twice as many exercises were devoted to measuring Objective I as were used for all of the other objectives combined. No explanation for this apparent im-

balance has been offered by NAEP. One can only speculate that Objectives II, III, and IV were felt to be less measurable *with large numbers of people, less important, or perhaps* more demanding of time and resources than NAEP could devote to them.

Whatever the reason, the inescapable result is that Objectives I and II are the only areas in which the number of released exercises provides a basis for even the most tentative of conclusions. Among released exercises there seems to be no evidence of attempts to measure Objectives II-A or II-I, III-B or III-F, IV-D, or IV-E. Further, this committee feels that virtually all of the Objective IV released items are of such doubtful face validity that they provide no useful information about science attitudes or appreciations.

With respect to Objective I items, certain areas, such as astronomy, ecology, electricity, evolution, and genetics were much less emphasized at all age levels than were such areas as mechanics and kinetics, the structure of matter, and health and body functions. It is somewhat surprising to find this distribution in view of the kinds of school science programs now in operation, particularly for 9's and 13's. The prevalent text materials of the 1960s probably did not emphasize genetics, evolution, or ecology. Astronomy and electricity, however, are old standards in many elementary programs. On the other side, the relative emphasis on mechanics, kinetics, and the structure of matter as contrasted with the light treatment given to weather, plants, animals and even health, especially for 9's, 13's, and 17's, seems inappropriate for elementary school science.

### Administration of the Exercises

The approximately 450 different science exercises were divided among 47 packages which also contained items assessing achievement in writing and citizenship. The packages were administered by specially trained personnel. Group-administered exercises were presented on tape to standardize procedures and to facilitate the efforts of subjects with poor reading abilities. Individually administered packages were presented in an interview mode that was highly standardized. In all cases, ample time was given to subjects to complete all the exercises. In-school subjects took only one package of materials requiring less than an hour to complete. Out-of-school subjects sometimes took up to four packages. [9]

### Reporting the Results

Three main methods have been used to report the data resulting from the assessment efforts. The first method is simply that of item-by-item reporting of the national performances in terms of the percentage of respondents choosing each possible answer. This procedure has been carried out for the approximately 40% of the items released by NAEP. This procedure is demonstrated as follows for an item given to both 13- and 17-year-olds. The actual text and the national results for each of the released items are included in Appendix V of this report. To describe the performance of a particular subgroup of the national sample on a collection of items, NAEP reports the median value of the distribution of "percentage correct" for the collection. It is reported, for instance, that adults scored on the average at a level of 54.5 on the 85 items assessing Objective I. This score was determined by examining the distribution of percentage correct scores for all the items given to adults assessing Objective I and finding the median of those percentages.

Display of Results for 13- and 17-Year-Old National Samples

In terms of the theory of natural selection, what is the explanation of why giraffes have come to have such long necks?

| Age 13 | Age 17 | | |
|---|---|---|---|
| 8% | 12% | o | Stretching to get food in high trees has made their necks longer |
| 2 | 1 | o | There is something inside of giraffes which keeps making longer necks. |
| 11 | 6 | o | Giraffe food contained vitamins which caused the vertebrae to lengthen. |
| 28 | 13 | o | Giraffe necks have gotten longer and longer as time has gone on, but nobody has any idea why this is. |
| 38 | 58 | • | Giraffes born with the longest necks have been able to stay alive when food was scarce and have passed this trait on to their offspring. |
| 12 | 10 | o | I don't know. |
| 0 | 0 | | No Response |
| 99% | 100% | | |

• indicates correct answer

A second method of reporting involves making item-by-item comparisons between the performance of various subpopulations identified in the assessment. For instance, when males are compared with females the difference in percentage correct is given as an estimate of the advantage one group has over another on a particular item. More specifically, if for an item dealing with atomic theory, 80% of the boys taking the item responded successfully and 75% of the girls responded successfully, the difference between these percentages (+5%) is reported to estimate the sex difference (in favor of boys) found on that particular item. If the comparisons involve more than two groups, such as regions of the country (Northeast, Central, Southeast, and West), a comparison is made between the percentage of success of respondents in each region with that in the nation as a whole. For instance, if on the item dealing with atomic theory, given as an example above, the percentage of success of Northeast respondents were 90% and the national level of success were 75%, then the Northeast effect would be defined as plus (+) 15%.

A third method was used to describe the performances of subpopulations on collections of items. To this end, the differences for a particular subgroup determined as described above for each item are placed in a distribution. The median of that distribution is taken as the typical "effect" or typical performance in that group. For instance, all the items included in the assessment at age 9 could be ranked in terms of the differences between the performances of respondents from the Southeast and from the country as a whole. The median of this distribution would represent the effect of living in the Southeast on the performances called for by the entire collection of assessment items. Comparisons of performance of two groups are dangerous since they can be

clouded by other variables. For example, an investigator might be interested in comparing the progress of males and females in our schools. In this situation, the investigator is faced with the problem that the subjects in the study are not only male and female, they are also Black or Non-Black, rich or poor, urban or rural. Any direct comparison between sexes is probably contaminated by other variables. To take another example, an investigator interested in comparing the performances of rural and urban populations might be properly concerned by the realization that a higher proportion of his rural subjects than of his urban subjects was drawn from the Southeast region of the United States. This concern is triggered by the finding that students in the Southeast performed lower on this assessment than did students from other regions of the country. If he were to make a comparison of unadjusted data, the investigator would not know whether observed differences reflected differences between rural and urban students or differences between regions (or some other variable) already detected. The Appendix of *Report 7* of the NAEP is an account of the procedures used to balance the data in making comparisons between groups. [10] Several limitations of this procedure described in that section of the report are abstracted here:

1. Balanced findings are hypothetical. They give estimates between groups after the groups have been statistically equated on several variables.

2. Not all relevant variables have been taken into account in the balancing process. For instance, the NAEP findings remain unbalanced for the variable "economic status."

3. The measures used to assess the variables of concern in the balancing process are far from ideal measures. For example, parental education as a variable is measured by "years in school."

With all of these limitations in mind, one must still say that the balancing process does reduce the credibility of some of the more "obvious" explanations that can be proposed for differences between subsamples reported by the NAEP. If differences in performances between two regions of the country are reported as "balanced," then it is very unlikely that those differences can be accounted for by differences which occur between those regions in the percentages of urban and rural students, Black and white students, etc. The process of balancing has equated the regions on these variables and on others, yet the differences are still apparent. In this case, we need to look beyond the variables utilized in the balancing procedures to find reasonable explanations of the observed differences.

It is very important to stress the hypothetical nature of balanced results. Balancing is a procedure that statistically equates groups on selected variables. Thus, balanced findings would compare the Northeast with the Southeast considering that Blacks and Non-Blacks, urban and rural, and inner-city people and suburban fringe people were found in equal proportions in both regions. Clearly, this is not the case in real life, but it might be interesting to observe the differences between regions if that were indeed the case *hypothetically*. In this report, the balanced findings are for the most part ignored. They are probably of interest to scholars pursuing questions other than that posed to our study team. Practitioners need to be concerned with real values and not hypothetical ones. As the NAEP report stipulates, "The problem facing the schools is usually better shown by unadjusted values." [11] Unless otherwise specified, all the findings included in this report are unadjusted.

No results for individuals, schools, school systems, or states are available. The smallest geographical areas for which data are reported are the four quarters of the United States. Breakouts are reported for sex, color, size and type of community, levels of parental education, and regions of the country. In the next cycle, the NAEP will be collecting additional data on each respondent so that findings can be correlated with the amount of science taken and with experiences with particular modern science curricula. (See Appendix III. In addition, from the outset NAEP has refrained from interpreting the data or drawing recommendations from them. From time to time, however, explanations from outside experts, judges, and others have been included in the publications emanating from its office. In the main, however, it has seen its role as encouraging others to examine and interpret the findings. NAEP has published some interpretations offered by scientists, science teachers, and others interested in science education in their newsletters and other publications. [12] Many other sources of information are available through either the Government Printing Office or the NAEP itself. Interested persons may write to National Assessment Mailing List, Department of Communications and Public Relations, 300 Lincoln Tower, 1860 Lincoln Street, Denver, Colorado 80203, for a current list of available publications.

*References*


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10. National Assessment *Report 7. 1969-1970 Science: Group and Balanced Group Results for Color, Parental Education, Size, and Type of Community and Balanced Group Results for Region of the Country, Sex.* Education Commission of the States, Denver, Colorado. December 1971. Appendix B.

11. *Ibid.*, p. B-10.

12. *National Assessment of Educational Progress. Report 1. Science: National Results. Observations and Commentary of a Panel of Reviewers.* Education Commission of the States, Denver, Colorado. July 1970. (For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Price 50 cents.)

# FINDINGS OF THE FIRST ASSESSMENT

This section describes selected findings of the first science assessment, 1969-70. The information reported here does not begin to exhaust the enormous amount of data already collected by NAEP in its first effort. In addition, a second assessment has been completed since our study team initiated its work in the fall of 1972. Hopefully, the findings reported here will encourage readers to seek out additional information from the NAEP and from the professional literature.

### Objective I—Knowledge of Science

Sixty-nine percent of the exercises in the NAEP instruments were directed toward assessing Objective I—knowledge of fundamental facts and principles of science. The NAEP analysis roughly divided the items into biological science, physical science, and other. The findings for the former two subgroupings as well as the overall results are reported in Table 5 for each age group. The percentage of respondents within a particular age group who got an item correct was used to rank all the items. The median value of this set is reported as the median P-value of a collection of items. Thus, if the median P-value for 9-year-olds is given as 66.5, it means that if all the items given to 9-year-olds in that classification were ranked according to the percentage of respondents getting the item correct, the median of such values is 66.5.

- In terms of percentage correct values, the 9-year-olds performed highest, followed by the 13-year-olds, the young adults, and finally the 17-year-olds. (It should be noted that for the most part, the different age groups were responding to different items. These data do not take into account differences in the inherent difficulties of the items.)
- Percentage correct values tended to be higher for items classified as assessing knowledge in the biological sciences than in the physical sciences with the largest discrepancy in the 9-year-old group.

Table 5. Median P-values (Percentages Correct) for the National Sample of Nine-Year-Olds, Thirteen-Year-Olds, Seventeen-Year-Olds, and Young Adults on Objective I—Knowledge of Science

| Age Level | Physical Science | Biological Science | All Items[1] |
|---|---|---|---|
| Nine | 66.5 (61 items) | 77.7 (33 items) | 70.3 (96 items) |
| Thirteen | 55.5 (43 items) | 58.2 (31 items) | 57.4 (75 items) |
| Seventeen | 44.6 (60 items) | 53.9 (29 items) | 47.6 (89 items) |
| Adult | 52.1 (46 items) | 55.8 (38 items) | 54.4 (85 items) |

[1]Some items not classified as either physical science or biological science

### Objective II—Abilities in the Process of Science

Twenty-one percent of the exercises in the NAEP instruments were directed toward assessing Objective II—abilities and skills needed to engage in the processes of science. In a manner similar to that used above for Objective I, the findings relevant to Objective II are reported in Table 6 for each age level assessed and for two subgroupings of items (biological science and physical science) and for all items.

Table 6. Median P-values (Percentages Correct) for the National Sample of Nine-Year-Olds, Thirteen-Year-Olds, Seventeen-Year-Olds, and Adults for Objective II—Processes of Science

| Age Level | Physical Science | Biological Science | All Items[1] |
|---|---|---|---|
| Nine | 64.3 (16 items) | 59.1 (10 items) | 66.5 (29 items) |
| Thirteen | 59.1 (23 items) | 60.7 (7 items) | 59.1 (31 items) |
| Seventeen | 45.1 (18 items) | 55.6 (3 items) | 52.4 (24 items) |
| Adult | 51.2 (16 items) | 70.0 (0 items) | 51.1 (24 items) |

[1]Some items not classified as either physical science or biological science

### Objectives III and IV—The Investigative Nature of Science and Attitudes and Appreciations

The NAEP project was to assess two other objectives. Objective III was aimed at the understanding of the investigative nature of science. Objective IV was geared to the development of attitudes about and appreciations of scientists, science, and the consequences of science that stem from adequate understandings. Only 6% of all the items found in the NAEP instruments were directed at Objective III, and another 6% were written toward Objective IV. The number of items were too few, in the opinion of the study team, to report those findings.

- In terms of percentage correct values for all the items assessing Objective II, the 9-year-olds performed highest, followed by the 13-year-olds, the 17-year-olds, and finally by the adults. (Again, the subsamples were in the main responding to different items. These data do not take into account the inherent difficulties of the different items.)

### Overlap Items

One difficulty associated with interpreting the findings reported in the previous paragraphs is that they are derived

for the most part from different sets of exercises. The variability in the scores may be accounted for more by the difficulty of the items than by attainments in school. To throw some light on this area, the NAEP design did provide for some overlap items which were administered to subjects at more than one age level. Table 7 illustrates some of the topics included in the overlaps and the relative performances of three age groups.

Table 7. Illustrations of Performances of Thirteens, Seventeens, and Adults on Selected Exercises[1]

| Exercise Content | Age Level | | |
|---|---|---|---|
| | 13 | 17 | Adults |
| | *percent* | *percent* | *percent* |
| Analyzing tables to determine weight of object | 62 | 81 | 63 |
| Result of repeated scientific measurement | 69 | 72 | 57 |
| Timing a pendulum | 38 | 56 | 49 |
| Characteristics of air masses in predicting weather | 59 | 77 | 85 |
| Effect of changing a member of an ecosystem | x | 68 | 52 |
| Adrenaline, a heart stimulant | x | 56 | 70 |
| Function of placenta | x | 41 | 45 |
| Purpose of a fuse | x | 49 | 64 |

[1]This table was taken from National Assessment of Educational Progress, *Summary of Report 1. Science: National Results*, July 1970, p. 12.
xNot asked of this age level

- The 13-year-olds outperformed the 9-year-olds on all 14 of the exercises given to those two groups. The topics treated in the released exercises included health and body functions, weather, and the processes of science.
- The adults outperformed the 9-year-olds on all 11 of the overlap items addressed to Objective I of those two groups. None of these items was released. The adult group also performed better than the 9-year-olds on two items assessing higher objectives.
- On 13 items addressed to Objective I and given to both the 13-year-olds and the 17-year-olds, the latter group outperformed the former in each case. The released items covered the topics of comparative animal structures, health, and body functions. On 10 items assessing higher objectives, the 17-year-olds again outperformed the 13-year-olds.
- On 19 of the 27 items given both to adults and to 13-year-olds addressed to Objective I, the adults did better than the younger respondents. The one item of the 8 exceptions that was released dealt with the movement of molecules in hot water as opposed to cold water. For 14 items measuring achievement at objectives higher than knowledge, the adult group outperformed the 13-year-olds on all but two of them. The one released item in this latter category dealt with the expected imprecision of scientific measurements. More adults expected all measures to be exactly the same.
- On 21 of the 36 items addressed to Objective I and given to both the 17-year-olds and to the adults, the 17-year-olds did better. The adults did better than the 17-year-olds on items dealing with the time of release of the egg in the human female menstrual cycle, the purpose of the fuse in an electric circuit, heart stimulant, function of the placenta, and estimating the velocity of a boat moving in a current. On all but one of the 20 overlap items given to both 17-year-olds and to the adults addressed to objectives higher than Objective I, the 17-year-olds did better. This one item was not released.
- There were six exercises given to 13-year-olds, 17-year-olds, and to adults. In five of the six items the 17-year-old group outperformed the other two groups. The adults scored high on an item dealing with weather predicting.
- Adults used the "I don't know" response more often than did any of the other groups.

### Males and Females

The National Assessment reports detailed observed differences between performances of males and females. To determine the differences, the percentage of females performing correctly on an item was subtracted from the percentage of males successfully answering the item. These differences were than ranked, and the median difference was identified for each age group. (See Table 8.)

Table 8. Median Male-Female Differences in Percentage Correct at Four Age Levels

| Age Level | Median Differences on All Items |
|---|---|
| | *percent* |
| Nine | 0.5 |
| Thirteen | 1.7 |
| Seventeen | 3.0 |
| Adult | 9.7 |

- For items dealing with the biological sciences, the median of the differences between the sexes favoring the males remains small at all four age levels, rising from 0.1% at age 9 to 2.3% for adults.
- The average male advantage on physical science exercises rises from 0.8% at age 9 to 14.2% for adults.
- An exception to the overall trend was found on items dealing with knowledge of human birth and reproduction. In this area, females did appreciably better than males, especially at the adult level.

### Relative Performance of Blacks

The NAEP arranged to assess the relative performance of Blacks in our society by comparing their performance with the national median. At the time of testing, the color of each respondent was determined by the exercise administrator as assessment packages were collected. Color was reported as Black or Non-Black. To describe the relative standing of Blacks, the national percentage of correct responses for each item was subtracted from the Black percentage correct for that item. Within each age level, the distribution of differences was inspected, and the median was identified. The median value was taken as the estimate of the relative standing of Blacks within each age level. (See Table 9.)

Table 9. Median Relative Performance by Blacks for Exercises under Objective I, Objective II, Total Exercises, and Total Exercises (Balanced) at Four Age Levels

| Exercises | Age Level | | | |
|---|---|---|---|---|
| | 9 | 13 | 17 | Adult |
| | *percent* | *percent* | *percent* | *percent* |
| Objective I | −15.5 | −15.0 | −10.9 | −14.8 |
| Objective II | −17.7 | −18.7 | −19.6 | −17.8 |
| Total (All exercises) | −14.5 | −15.0 | −11.8 | −15.8 |
| Total (Balanced) | −10.2 | −11.0 | −7.7 | −10.9 |

- Blacks performed roughly between 12% and 16% below the national average at the four age levels: 9, 13, 17, and adults.
- Statistical procedures applied to the data by National Assessment analysts to estimate what the relative performances of Blacks might have been if they were represented proportionately in differing types of communities, in differing levels of parental education, and in various regions of the country moderated the observed differences somewhat. This statistical method, called "balancing" by NAEP, does not take all characteristics of respondents into account. (See our previous discussion dealing with the reporting of findings.) For instance, economic status was not measured directly, although this factor may have been reflected in some of the other variables taken into account, such as size and type of community, level of parents' education, and others. [1]

### Geographical Regions

A breakout of the data was also performed by dividing the United States arbitrarily into four regions, Northeast, Southwest, Central, and West. The specific states that were included in each of the regions are listed in the NAEP literature. [2] The purpose of this analysis was to estimate regional effects as reflected in the performances on the National Assessment instruments. A regional effect for each item was defined as the difference between the percentage correct for that region and the national percentage correct. By ranking all the items in terms of their effects, the NAEP determined the average effect by taking the median of the distribution of item effects. The findings of this analysis are reported in Table 10.

Table 10. Median Differences in P-values (Percentage Correct) for all exercises Between Regions and the National Median for Four Regions of the United States at Four Age Levels

| Age Level | Region | | | |
|---|---|---|---|---|
| | Northeast | Southeast | Central | West |
| | *percent* | *percent* | *percent* | *percent* |
| Nine | 2.2 | −5.1 | 1.6 | 0.0 |
| Thirteen | 2.0 | −4.8 | 1.9 | −0.6 |
| Seventeen | 2.4 | −4.8 | 0.0 | 1.7 |
| Adult | 0.7 | −5.1 | 0.6 | 2.6 |

- The median effect for the Northeast region at each age level was positive, indicating that Northeasterners generally performed better than did the nation as a whole.
- The median effect for the Southeast region at each age level was negative, indicating performance below the national level.
- The median values of the West region show the greatest variability in estimated effects—between that of the 13-year-old group and the adult group.
- Respondents in the Northeast region tended to perform better on Objective II items than on Objective I items.
- *Respondents in the Southeast region did relatively better* on items addressed to Objective I than to items written toward Objective II.

### Size and Type of Community

Another of the breakouts of the data reported by the NAEP related to the size and type of community in which the respondents lived. Several arbitrary classifications were made, including the following: extreme inner city; inner city fringe; extreme affluent suburbs; extreme rural communities, and other, as found in Table 11. The precise bases for these classifications are found in NAEP literature. [3,4] The data in Table 11 are similar to those reported in other sections of this report. They were determined in the following way. First, the national percentage correct for each item was subtracted from the percentage correct received by the membership of a particular subgrouping. Next, all the differences for a particular subgrouping were ranked and the median of those differences was determined.

Table 11. Median Effects by Size and Type of Community for Four Ages [5]

| Size of Community | Size and Type of Community | Age Level | | | |
|---|---|---|---|---|---|
| | | 9 | 13 | 17 | Adult |
| Big City | | −4.8 | −4.7 | −2.6 | −2.4 |
| | Extreme Inner City | −15.1 | −13.7 | −7.4 | −10.2 |
| | Inner City Fringe | −2.6 | −3.8 | −0.3 | −2.9 |
| Urban Fringe | | 3.0 | 3.4 | 2.4 | 3.2 |
| | Extreme Affluent Suburb | 7.2 | 6.3 | 5.1 | 10.9 |
| | Suburban Fringe | 2.7 | 2.9 | 1.0 | 0.8 |
| Medium City | | 0.8 | 1.1 | 0.8 | 0.4 |
| | Medium City | 0.8 | 1.9 | 1.2 | 0.4 |
| Small Places | | −1.2 | −1.1 | −2.1 | −2.8 |
| | Extreme Rural | −6.3 | −6.1 | −3.5 | −4.7 |
| | Small Cities | 0.9 | 0.5 | −1.4 | −2.7 |

- In the Big City category, respondents of age 17 showed a deficit of 2.6 but when this category was broken down into Extreme Inner City and Inner City Fringe the deficit appeared to be 7.4 for the former and a 0.3 advantage for the latter. The disparate results indicate the degree of variance found in the four gross classifications of size of community.
- Respondents from the Extreme Inner City show a large deficit when compared to national measures of central tendency.
- The performance gap between those from the Extreme Affluent Suburbs and the Extreme Inner City is largest at age 9, decreases at the 13- and 17-year-old levels, and increases sharply for the adults.

• The differences cited above seem to hold over various classifications of items: for physical science, for biological science, and for all four objectives assessed in the 1969-70 cycle.

• When statistical procedures are applied to the data to balance effects of differences between population characteristics, the effects found in Table 11 are essentially reduced 50%. Such manipulations, however, do not affect the deficit shown by Extreme Rural adults.

• The discrepancies between subcategories were the lowest at the 17-year-old level with the Extreme Inner City respondents having the smallest deficit at that age and the Extreme Affluent Suburban respondents having the smallest advantage. It is interesting to note that this narrowing of differences occurs at an age when most children have been recently exposed to formal science instruction.

### Parental Education

The findings of the NAEP project were analyzed in terms of the education levels of parents. Categories in this analysis included the following: (a) education level of parents not ascertained; (b) neither parent educated beyond eighth grade; (c) either mother or father had some high school but did not graduate; (d) either mother or father completed high school but neither educated beyond high school; and (e) either mother or father educated beyond high school. The data were treated as follows. Within each age level, the national percentage correct for an item was subtracted from the percentage correct of a particular subgrouping cited above. The difference estimated the effect on that particular item of belonging to that subgroup. The effects of all the items were then ranked from high to low for the subgroup, and the median of the effects was taken as an estimate of the average effect of subgroup membership over all the items. The results of this analysis are presented in Table 12.

Table 12. Parental Education Effects for Differing Levels of Parental Education for Each of the Age Levels[1]

| Age Level | No High School | Some High School | Graduated High School | Post High School |
|---|---|---|---|---|
| Nine | −7.2 | −4.8 | .6 | 5.8 |
| Thirteen | −11.8 | −6.2 | −1.3 | 5.2 |
| Seventeen | −8.4 | −7.6 | .1 | 5.1 |
| Adults | −7.9 | −1.6 | 3.0 | 9.1 |

[1]As in previous tables, students at the various age levels were administered different items so that comparisons across age groups are difficult to make.

• At the four age levels, 9, 13, 17, and adult, those respondents neither of whose parents was educated beyond eighth grade showed average effects ranging from approximately −7% to −12%.

• At the four age levels, the respondents whose parents had received some high school education manifested average effects which ranged from about −2 to −12 percentage points.

• At the four age levels, the respondents whose parents had graduated from high school showed average effects from −1 to +3 percent.

• At the four age levels, therespondents whose parents had received some post high school education demonstrated an average effect that ranged from about +5 to +9 percentage points.

### Performance Exercises

Included within the assessment exercises were a few items that differed qualitatively from the others. These items asked respondents not to choose the best response from a set of alternatives but rather to perform a task with simple equipment. For example, some of the items required respondents to operate a beam balance, to calculate the density of an object, and to time the swings of a pendulum. Curriculum developers during the last decade have given emphasis to performance skills as an outcome of science instruction, and it is very appropriate that performance items were included in the assessment. The number of such items in the 1969-70 assessment was small—3 released and 8 unreleased exercises for 13, 17, and adult—approximately 8% of the total.

• The absolute level of performance on these 11 items which required skills such as measurement, graphical analysis, and making inferences concerning operations with concrete materials was low; less than half of all the respondents showed these competencies.

• Respondents in the Affluent Suburbs displayed a substantial advantage in these tasks over Inner City populations.

• Non-Black respondents showed a large advantage over Blacks on these items.

• Males outperformed females on the performance items included in the assessment.

### Expectations

One of the problems in interpreting the results of the national assessment is that it is difficult to know what performances should be expected on particular items. All teachers know that test items assessing the same specific objective can vary in difficulty because of characteristics of the item. Distractors can be shaded or nuances introduced to make items which appear to be very similar have very different difficulties. An example of this problem in operation is found in comparing the performances of the various age groups. Overall the performance of the 17-year-olds in terms of percentage correct is lower than that of other age groups, and yet on the items that were overlapped across age groups, the 17-year-olds generally did better than did the other groups. One explanation for this apparent discrepancy is that the items given to the 17-year-olds were generally more difficult in a technical sense.

The study team examined each of the released items and for each age level classified them according to a general level of expectation. Some items were judged as measuring performances that all persons of that age group "should" have acquired. Other items were judged as measuring performances that approximately half of a particular age group should have acquired. Finally, some items were judged to be measuring performances that only very few of a particular age group "should" have acquired.

The distribution of the study team's judgments across age levels was reported in Table 4 in an earlier section of this report. An analysis was run to compare the actual performances of the various age levels with the expectations defined by the study team. The comparisons are reported in Table 13. The rows of Table 13 define intervals of observed percentage of correct responses on items within each age level. Three classifications are included in the table: those items for which the national percentage correct was between 75 and 100; those items for which the national percentage correct was between 50 and 74; and the items for which the national percentage correct was between 0 and 49. Extreme

Table 13. Number of Released Exercises Classified by Expectation Level as Judged by the NSTA Study Team and by the National Percentage Correct for Each Age Level

| Age Level | Performance Levels | Expectation Levels | | |
|---|---|---|---|---|
| | | Very Few "Should" Respond Correctly | About Half "Should" Respond Correctly | Almost All "Should" Respond Correctly |
| | *percent* | | | |
| Nine | 75-100 | 0 | 5 | 18 |
| | 50- 74 | 1 | 16 | 3 |
| | 0- 49 | 7 | 8 | 0 |
| Thirteen | 75-100 | 0 | 0 | 15 |
| | 50- 74 | 0 | 10 | 4 |
| | 0- 49 | 4 | 14 | 0 |
| Seventeen | 75-100 | 0 | 0 | 9 |
| | 50- 74 | 0 | 10 | 11 |
| | 0- 49 | 9 | 11 | 4 |
| Adult | 75-100 | 0 | 1 | 8 |
| | 50- 74 | 0 | 7 | 10 |
| | 0- 49 | 9 | 12 | 2 |

care needs to be given to the interpretation of these findings. As cited earlier in this report, there was a great deal of disagreement among the study team members in their judgments about expectations. Second, most of the study team had had an opportunity to peruse the findings related to each item prior to the time they were called upon to make their judgments. There is no estimate of the bias this factor may have introduced into the process.

- The 9-year-olds performed closest to the study team's expectations, with the 13-year-old group performing next closest to expectations.
- The 17-year-old group was the most discrepant in deviating from the study team's expectations.
- Expectations of the study team tended to exceed actual performance, especially in the 17 and adult age levels.

*References*


1. National Assessment of Educational Progress. *Report 7. 1969-1970 Science: Group and Balanced Group Results for Color, Parental Education, Size, and Type of Community and Balanced Group Results for Region of the Country, Sex.* Education Commission of the States, Denver, Colorado. December 1971. P. B-10.

2. National Assessment of Educational Progress. *Report 1. 1969-1970 Science: National Results and Illustrations of Group Comparisons.* Education Commission of the States, Denver, Colorado. July 1970. Appendix B.

3. *National Assessment Report 4. 1969-1970 Science: Group Results for Sex, Region and Size of Community.* Education Commission of the States, Denver, Colorado. April 1971. Appendix B-1. (For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Price $1.00.)

4. Definitions of sizes and types of communities are also found in *Report 1* cited above (reference 2).

5. Report 7, *Op. cit.*, p. 51.

# JUDGMENTS AND CONCLUDING STATEMENTS

## Judgments

The following statements represent the specific judgments the members of the study team feel were warranted at this time. Specific recommendations based on these concluding remarks have been transmitted to NAEP.

1. One of the most striking findings of the science assessment has to do with the comparatively poor performance of females compared to males. It is made especially noteworthy by the fact that in all of the assessments available to the study team at this time, science is the only area in which males outperformed females. (See Appendix III of this report for further comparisons among assessment findings.) While other industrial societies apparently make full use of their female citizens to meet the demands for highly skilled technicians and scientists, the United States is lagging in this regard. The findings here do nothing to make us optimistic about the future involvement of women in the sciences. Science teachers must become especially sensitive to their behaviors that may turn women away from science and science achievement.

The NSTA should appoint a committee to review the progress that has been made by females in the science areas and to identify systematic factors that may be impeding the progress of women in the study of science.

2. On 21 out of 36 overlap items, the 17-year-olds did better than did the young adult group. It may be that much of science content is recondite—and subject to rapid forgetting on the part of students. Teachers need to inspect their goals to identify those which are especially narrow. For items that are deemed important, efforts need to be made to find methods of teaching that will contribute greater retention.

One approach is to concentrate on science methods which have a high probability of making every student an autonomous learner. Instead of relying on teacher lectures and canned programs, more efforts could be expended toward inviting students to participate in independent learning activities which involve the science content thought to be important.

3. Assuming that the objectives assessed by National Assessment of Educational Progress are appropriate to the general student population found in the public schools and not to an elite group, it is clear that something systematic is preventing these objectives from being attained in equivalent ways by Blacks, by rural students, by Southeastern students, by inner-city students, and by females. While many factors may contribute to the observed differences, it is important that science teachers take the following into account:

a. Given the ranges of scores within each of the subsamples reported in the NAEP publications, being a girl, being Black, being a student in the Southeast—none of these factors either singly or in combination is an absolute barrier to high achievement in science.

b. While one goal of schools is to widen the differences found in children, to promote intellectual diversity rather than conformity—it is counter to the goals of education in their most profound sense and to the ideals of the American society for the diversity to be systematically accounted for by factors of color, sex, or neighborhood. It is commonly assumed that teachers will take steps to ensure that their teaching methods and their attitudes, conveyed by what they do and what they say, transmitted formally or informally, do not discriminate against subgroups of students.

3. An examination of those items assessing knowledge in the area of sex education indicated that the 17-year-olds, as a group, did poorly and the adults performed only somewhat less poorly. One possible inference from these findings is that sex education is needed in our schools. With the rather poor showing of the adults, there may be a basis for believing that parents may not know enough about sex education to be competent teachers of their children in this area.

## Concluding Statements

The study team is aware of the rather bland nature of these judgments. We had hoped that an examination of the data would allow us to write recommendations suggesting practical and profound changes in funding, in teaching practices, in curricula policies, and in other significant aspects of the science teaching enterprise. We find now that none of the tentative statements we have drafted is particularly fresh or insightful. Policy-making groups will probably not be able to act on our recommendations to the benefit of science students throughout the nation. An explanation for our failure to date to identify great significance in the data may lie in the various contexts in which the study team was operating and in which the National Assessment of Educational Progress project was carried out. Those contexts seem worthy of discussion here.

*Context of time:* The National Assessment of Educational Progress must be seen as a long-term effort. From its outset, the project was designed to assess changes in the attainments of young Americans *across time*. In this light, it is perhaps premature to seek interpretations of the results of the first testing. The importance of the NAEP findings may not become clear until the fourth or fifth cycle. To become impatient after only one or two rounds is seemingly to misjudge a significant character of this project: testing across several time periods.

Accepting this view, the study team anticipated what might be said about similar findings even if several data points over time were available. Our thinking included the following points:

1. Approximately 60% of the items used in the 1969 administration were repeated in 1972. For those items, differences between performance can be taken as measures of trends. For instance, perhaps more children will be able to handle a beam balance in 1972 than could do so in 1969. While two data points hardly provide definitive support for a trend, points found in subsequent assessments should be of some interest to science educators.

2. We can anticipate that the percentage of correct responses for a given item will fluctuate over time. However, as changes are identified, it will be difficult to identify the causal factors which account for the changes. The data reported by National Assessment of Educational Progress are not being collected in a laboratory—but in the real world. There are many variables which can be considered as reasonable explanations for the differences observed in the NAEP findings over time—television, systematic changes in school curricula, and influences of dramatic scientific achievements, to name only a few. Additionally, these variables and many others not named here must not only be assessed in terms of their direct effects on the NAEP findings, but also as they interact with each other to alter the educational attainments of our young citizens.

3. As changes are identified over the cycles of assessments that are to take place in the next several decades, it must be remembered that it is not the case that increased achievement on an item is *ipso facto* good and a decreased achievement level is bad. A downward shift in some areas and on some items might signal a welcome change away from teaching trivial bits of information while an increasingly high performance on an item might be an indication that our schools are still teaching in old and unwanted ways.

In sum, it may be the case that the possible significant contributions of NAEP cannot be discerned at this time; that the assessment project will gain in significance and importance only after a series of measures is taken. It was not clear to our team, however, that much could be made from such trends—even if they were quite definitive.

*Context of measurement strategies:* Many advocates of the National Assessment of Educational Progress undertaking argued initially that the project will provide legislators, policy makers, professionals, and citizens of this country with reliable information about the educational enterprise. It was hoped that, armed with this valuable information, the various publics to which the educational establishment is accountable would be in a better position to make decisions necessary for the provision of quality education. While the exact form of the information to be provided by NAEP was not made clear, allusions were made to the formulation of a complex indicator of the status of education, a statistic similar to that of the Gross National Product. While few citizens can define explicitly the variables that are included in the formulation of the GNP and even fewer can identify the weightings that are applied to combine the variables into an index, nevertheless, the Gross National Product is apparently a very meaningful measure. The literature discussing the potential payoffs of the NAEP almost always imply that such an index would be one of the useful products emanating from this effort.

However, the conception of the assessment task on the part of the professionals has been from the beginning based generally on a behavioristic tradition. Item writers, from the first, were not asked to develop exercises that would contribute to the measurement of such constructs as "educational quality" or "knowledge of science." Instead, each item was to stand as important by itself. It follows from this position that the findings, including the breakouts of the performances of the various subgroups, were to be considered important in their own right—and not as they contributed to the validity of a grand index or construct on the scale of GNP. The study team attempted to impose some constructs of its own on the data—for instance, to pool items appearing to measure achievement in the area of weather or plants. We had little success for two reasons. First, the reliability with which we classified items into categories was suspect. Second, once the categorizations were made—we had very few items in our cells (see Table 2). This result was to be expected since the items were not developed to be clustered in this way. The recognition of this context may contribute to the appreciation of the difficulty we have had in extracting meaning from the first-round findings. The difficulties can be elaborated in the following points:

1. Each item was designed to stand alone. Thus, if students did poorly on an item in a field of study, there is no way that science teachers can know that the entire field of study needs upgrading. The one item may not represent students' progress in that area.

2. Very few items were written for the more complex objectives. One explanation for this lies in the choice of testing format which almost precludes assessment of these objectives. Therefore, our team had very little information relevant to this highly important aspect of science teaching to interpret.

*Context of comparisons:* The comparisons the National Assessment of Educational Progress did choose to make in its reports might be another source of the difficulties our study team experienced. Knowing that Blacks score higher than Non-Blacks on a particular item—or that males score higher than females on another—is not as edifying as other comparisons that might have been. For instance, if students could have been grouped by science curricula, or by years of receiving science instruction, to name two, perhaps more meaningful statements could have been made at this time. The comparisons reported seem on the whole rather gratuitous. For instance, we wonder how teachers could make use of the information that one section of the country scored higher than another.

*Context of controversies in education:* A final context which may account in part for our difficulty in finding more important recommendations to advance after studying the NAEP results lies in current conflicting views of the educational enterprise. By placing a focus on the outputs of the educational process, the National Assessment of Educa-

tional Progress seems to be accepting a technological metaphor, viewing education through a separation of ends and means. One of the obstacles facing our study team was the difficulty on the part of some members of accepting the view that the quality of education can be assessed by the examination of multiple-choice test results.

It is our fervent wish that after baseline data lines are established and with the addition of the second-round results, then more specific and meaningful recommendations may be gleaned from the NAEP results.

*References*


1. National Assessment of Educational Progress. *Report 1. 1969-1970 Science: National Results and Illustrations of Group Comparisons*. Education Commission of the States, Denver, Colorado. July 1970. (For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Price $1.75.)

2. National Assessment of Educational Progress. *National Assessment Report 4. 1969-1970 Science: Group Results for Sex, Region, and Size of Community*. Education Commission of the States, Denver, Colorado. April 1971. (For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Price $1.)

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# APPENDIX I

## PROFILE OF STUDY TEAM MEMBERS

Readers of this report may be curious about the credentials of the members of the Study Team. The following paragraphs describe important aspects of their backgrounds.

**James Raths** is the chairman of the Department of Elementary Education at the University of Illinois-Urbana. At the time the NSTA Study Team was appointed, he was Director of the Bureau of Educational Research and Field Services at the University of Maryland. He has been interested for many years in relating teaching strategies and curriculum decisions to measures of student outcomes.

**Julian R. Brandou** is presently director of the Science and Mathematics Teaching Center at Michigan State University. He attended the University of Michigan, completing the BS with majors in chemistry and general science. He then taught in two Michigan school districts, has served in the Chemical Corps of the U.S. Army, and has been a Traveling Science Teacher. In 1959 he went to Michigan State University where he helped train other NSF Traveling Science Teachers and also, subsequently, completed his PhD. He has been on the Center staff since then. He has served as president of the Michigan Science Teachers Association and as a regional director on the NSTA Board of Directors.

**Wilmer Cooksey** teaches chemistry at Woodrow Wilson High School in Washington, D.C. He received his undergraduate degree in natural and biological science at Bishop College, Marshall, Texas; he has an MEd from the University of Maryland. His experience has been largely concentrated in the inner city at the secondary level. He spent one year at the University of Maryland as a teaching associate, and is currently working with Maryland's University College as a chemistry laboratory instructor. He has recently been appointed to the advisory board of *Chemistry* magazine. He was selected Outstanding Science Teacher of Washington, D.C., in 1961.

**Fred D. Johnson** is presently secondary science consultant for Shelby County Schools, Memphis, Tennessee. He is a graduate of Tennessee State University and Memphis State University and is presently enrolled in a doctoral program at the University of Tennessee. He has served on the BSCS steering committee and was awarded the Outstanding Science Teacher Award by the Tennessee Academy of Science in 1971.

**Richard Kay** is consultant in science and mathematics with the State Department of Education in Idaho. With a BS in biology from Brigham Young University and an MS in science education from the University of Utah, Mr. Kay is currently doing graduate work for the doctorate at the University of Colorado. He has had teaching experience at high school and college levels. He served on the board of consultants for the NSTA study of exemplary science facilities. His state activities include director of Project Idaho and chairman, State Advisory Committee on Environmental Education.

**Morris R. Lerner** is a physics teacher and chairman of the science department, Barringer High School, Newark, N.J. He attended New York University (BS, physics; MS, science education), and has done further graduate work at NYU, MIT, and the University of Colorado. He has been coordinator of the MAT program in science and mathematics at Fairleigh Dickinson University and is an adjunct professor at Rutgers University. He was the 1971-72 president of the National Science Teachers Association and is a member of the Council on Physics in Education of the AAPT. He has for many years been active in developing science courses for inner-city youth, and he designed and put into operation one of this country's first integrated science courses.

**Richard J. Merrill** is consultant in secondary curriculum, Mt. Diablo Unified School District, Concord, California. He received his BS in chemistry from the University of Michigan, his MA and EdD degrees from Teachers College, Columbia. He taught high school chemistry and served as coordinator of secondary science in the Riverside, California, city schools. Merrill has served as executive director of the Chemical Education Materials Study and is a recent past president of the National Science Teachers Association.

**Joseph A. Struthers** is a sixth-grade teacher at Mesa Elementary School in Boulder, Colorado. After serving as a naval aviator, he began his teaching career as science and mathematics teacher in small Colorado high schools. He became involved in PSSC as a physics teacher in Cheyenne Mountain High School in 1959, and three years later joined the Colorado State Department of Education as science and mathematics consultant, subsequently becoming head of the NDEA Title III Section. In 1966, he accepted an assignment as director of an ESEA Title III project in the Boulder, Colorado, schools. He has taught summer courses at Colorado College, Denver University, and the University of Colorado. He received BA and MBS degrees from the University of Colorado and has continued postgraduate work at Brooklyn College, Oklahoma State University, and the University of Northern Colorado at Greeley.

**Leslie W. Trowbridge,** professor of science, Department of Science Education, University of Northern Colorado, Greeley, began teaching in 1941 and has taught continuously since then with the exception of four years as a meteorologist in the US Air Force in World War II. He has taught at junior high, senior high, and college levels in the areas of physics, physical science, meteorology, and science education. He received a BS degree from Wisconsin State University, MS degrees from the University of Chicago and the University of Wisconsin, and a PhD from the University of Michigan. Professor Trowbridge is currently president-elect of NSTA. He served on the facilities study committee of NSTA and on the issues committee four years (one year as chairman).

**James R. Wailes** is professor of science education at the University of Colorado in Boulder. He is former chairman of the Division of Elementary Education. Professor Wailes received his BA (science and mathematics) and MA (elementary education and botany) from the University of Northern Colorado. His PhD was awarded by the State University of Iowa in elementary education and botany. His experience includes teaching at all levels (K-12) in the public schools, and he has served as an elementary school supervisor and principal. Professor Wailes has served as the director of 30 NSF

programs for the implementation of new science curricula and worked one year as an assistant program director for NSF in Washington, D.C. He has served on several NSTA committees and also as a member of the executive committee of the Board of Directors.

**Charles N. Wilson** was at the time of his appointment to the NSTA study team the chairman of the science department, New Dorp High School, Staten Island, New York. Mr. Wilson received his BS degree from City University of New York in 1947. He has been teaching science in secondary schools for 17 years—including general science and chemistry. Mr. Wilson served on the program committee for the 1972 NSTA national convention. He has recently been promoted to an administrative post in the New York City school system.

# APPENDIX II

# CHANGES IN ASSESSMENT PROCEDURES 1972-73

One of the serious handicaps in writing this report has been that while the study team has focused upon the 1969-70 assessment, the NAEP has carried out a second science assessment and is making plans for carrying out the third. Many of the comments and descriptive statements for the NAEP procedures are, in a sense, out-of-date. While they do indeed describe accurately the practices of NAEP in 1969-70, they do not take into account the many changes adopted for the current assessment. The purpose of this section of the report is to indicate several of the shifts that have taken place.

First, the objectives for the second cycle have been restated. They now include the following: I. Know the fundamental aspects of science; II. Understand and apply the fundamental aspects of science in a wide range of problem situations; and III. Appreciate the knowledge and processes of science, the consequences and limitations of science, and the personal and social relevance of science and technology in our society. In a sense, these objectives include those advanced in the first assessment but the statements were modified so as to show the relationships between behavioral processes and the fundamental aspects of science.

Second, in the 1972-73 assessment there is a larger number of exercises for Objective II than for Objective I. This is a decided shift from the distribution of items found in the first round. The following table displays the distribution of items for the second cycle. This shift in emphasis is in accord with some of our recommendations.

Table 14 Distribution of Exercises in the 1972-73 Assessment of Science by Age Level and Objective

| Age Level | Objective I | Objective II | Objective III |
|---|---|---|---|
| Nine | 62 | 89 | 10 |
| Thirteen | 66 | 85 | 15 |
| Seventeen | 55 | 79 | 17 |
| Adult | 24 | 44 | 13 |

Third, the proportion of open-ended questions in the second science assessment and the portion of exercises requiring the manipulation of apparatus is being appreciably increased. Again, this trend is consistent with our recommendations.

Fourth, the NAEP plan to collect more data on the students involved in the assessment that might add meaning to the findings. Specifically, they intend to find out the extent to which the students have been trained in science, the percentage of time devoted to science instruction involving laboratory work, the availability to students of special laboratory work stations, and finally the degree to which students were exposed to modern science programs such as SAPA, ESP, SCIS, etc. Such data should make the findings of the next round much more meaningful to science educators.

Finally, to increase the participation of 17-year-olds and young adults who are out of school, volunteers will be paid at the rate of $5 per package up to a maximum of four packages. None of the science respondents was paid for cooperation in the round-one assessment.

As far as we know, these changes do not exhaust those that have been adopted by NAEP for the second cycle of assessment. They do include those changes which are most directly related to the recommendations advanced elsewhere in this report.

# APPENDIX III

# INTERRELATIONSHIPS BETWEEN FINDINGS IN NATIONAL ASSESSMENT SURVEYS OF SCIENCE, READING, AND CITIZENSHIP

School learning is not unilateral. Students experience a wide spectrum of learnings at all levels. The typical educational experience is a blend obtained by exposure to and selection from a variety of separate disciplines presented in greater or lesser measure. It is inevitable that interrelationships between the various disciplines will develop, and these must be considered as a normal result of the systems and patterns of education extant in the United States. This section of the report deals with interrelationships between the results obtained in national assessment surveys of science, reading, and citizenship reported to date.

The reading and literature assessments were conducted from October 1970 through August 1971. These efforts followed by approximately eighteen months the assessments of science, writing, and citizenship, which were conducted between March 1969 and February 1970. Populations assessed were similar in age categories—9-year-olds, 13-year-olds, 17-year-olds, and young adults (ages 26-35). Data presented in each of the surveys were likewise categorized according to region, sex, size and type of community, race, and parents' high school education.

Six objectives were established in the reading survey, five of which had exercises included in the assessment. The objectives were:

1. Comprehend what is read
2. Analyze what is read
3. Use what is read
4. Reason logically from what is read
5. Make judgments concerning what is read
6. Have attitudes about and an interest in reading

The final objective in this list (No. 6) was not assessed in 1970-71.

Study of these objectives reveals similarities to those of the science survey which were categorized, however, in somewhat different form. The science objectives were:

1. Know the fundamental facts and principles of science
2. Possess the abilities and skills needed to engage in the processes of science
3. Understand the investigative nature of science
4. Have attitudes about and appreciation of scientists, science, and the consequences of science that stem from adequate understandings.

The objectives of the reading survey do not contain items comparable to the first objective in the science survey—Know fundamental facts and principles of science— mainly because reading is itself a process and a skill rather than a body of knowledge.

In comparing the second objective of the science survey—Possess the abilities and skills needed to engage in the processes of science—with the first five objectives of the reading survey, it becomes apparent that many similarities exist. The skills and processes of comprehending, analyzing, using, reasoning logically, and making judgments require essentially the same kinds of mental operations whether they involve science materials, reading materials, social studies materials, or any other subject.

When one compares the number of exercises written for the National Assessment surveys in science and reading in the respective objective categories, the disparity of emphases becomes apparent. The distribution of exercises for the science objectives is shown in Table 15.

Table 16 shows the distribution of objectives in the reading survey. It can be seen in Table 15 that science devoted 68% of its exercises to Objective I, "Know fundamental facts and principles of science." Reading, by comparison, had no exercises of a comparable type. Science devoted approximately 27% of its exercises to Objectives II and III, "Possess the abilities and skills needed to engage in the process of science" and "Understand the investigative nature of science." Reading, on the other hand, devoted all of its exercises to Objectives 1-5 which dealt with processes and skills of comprehending, analyzing, reasoning, using what is read, and

Table 15. Categories of Science Objectives

| Age Level | Objective | Released | Unreleased | Percent of Total | |
|---|---|---|---|---|---|
| | | | | (n) | percent |
| Nine | | 40 | 57 | | |
| Thirteen | | 28 | 47 | | |
| Seventeen | I | 38 | 51 | | |
| Adult | | 34 | 51 | | |
| Total | | 140 | 206 | 346 | 68 |
| Nine | | 12 | 16 | | |
| Thirteen | | 12 | 19 | | |
| Seventeen | II | 10 | 14 | | |
| Adult | | 11 | 13 | | |
| Total | | 45 | 62 | 107 | 21 |
| Nine | | 5 | 6 | | |
| Thirteen | | 4 | 4 | | |
| Seventeen | III | 3 | 3 | | |
| Adult | | 2 | 3 | | |
| Total | | 14 | 16 | 30 | 5.8 |
| Nine | | 1 | 8 | | |
| Thirteen | | 3 | 5 | | |
| Seventeen | IV | 3 | 2 | | |
| Adult | | 2 | 3 | | |
| Total | | 9 | 18 | 27 | 5.0 |

Table 16. Categories of Reading Objectives

| Objective | Number | Percent of Total |
|---|---|---|
| (1) Comprehend | 145 | 34.9 |
| (2) Analyze | 40 | 9.7 |
| (3) Use | 106 | 25.6 |
| (4) Reason logically | 43 | 10.4 |
| (5) Make judgments | 5 | 1.2 |
| (6) Have attitudes and interests about reading | 0 | 0.0 |
| (1 & 2) | 1 | 0.2 |
| (1 & 3) | 54 | 13.0 |
| (1 & 4) | 3 | 0.7 |
| (2 & 4) | 1 | 0.2 |
| Unknown | 19 | 4.1 |
| Total | 416 | 100.0 |

making judgments. Comparably, the science and reading surveys essentially omitted exercises purporting to assess objectives dealing with attitudes, interests, and appreciations (e.g., science 5.2%, reading 0.0%).

In the reading survey, a number of themes were identified and data were analyzed using these themes.

The reading themes are:

1. Word meanings
2. Visual aids
3. Written directions
4. Reference materials
5. Significant facts in passages
6. Main ideas and organization of passages
7. Inferences from passages
8. Critical reading of passages

When one examines the reading themes, it is evident that several of them may require competencies similar to those needed for success in science, particularly for higher level operations such as critical analysis, drawing inferences, or making judgments. To study this hypothesis, three of the reading themes were identified as having possible elements of commonality with the science objectives. They are identified as: using visual aids, following written directions, and picking significant facts from passages. The released science exercises were scrutinized for the employment of these particular skills. The average percent of success was computed and compared with the average percent of success on the reading exercises employing the same themes. Results of this investigation are shown in Table 17.

Table 17. Comparison of Science and Reading Results on Exercises Which May Require Similar Skills (9-, 13-, and 17-year-olds)

| | | Science | | Reading | |
|---|---|---|---|---|---|
| Skill | Age Level | % Success[1] | No. of Exercises | % Success | No. of Excercises[2] |
| Using Visual Aids | 9 | 69 | 5 | 79 | 14 |
| | 13 | 65 | 5 | 78 | 19 |
| | 17 | 75 | 2 | 83 | 14 |
| Following Written Directions | 9 | 68 | 10 | 78 | 6 |
| | 13 | 43 | 3 | 76 | 28 |
| | 17 | 75 | 1 | 73 | 16 |
| Picking Significant Facts from Passages | 9 | 41 | 8 | 51 | 13 |
| | 13 | 54 | 6 | 74 | 22 |
| | 17 | 35 | 11 | 84 | 22 |

[1]National percents of success on the exercises identified were averaged

[2]Data obtained from Report 02-R-20, 1970-71 Reading Assessment, Appendix A

For the 9-year-olds a high degree of similarity exists, with reading percentages being only slightly higher than science. For 13-year-olds, some disparity begins to appear, and for 17-year-olds, wide variations are evident, particularly in the ability to pick significant facts from passages. Since the correlation between science and reading results on this particular investigation seems to diminish from 9- to 13- to 17-year age levels, it may be that in science, the exercises chosen as exemplifying particular skills were complicated by other facts such as knowledge, reasoning ability, or familiarity with the problem of the exercises. Results for older children might be influenced more than those for younger children because of these factors.

A word of caution regarding interpretation of Table 17 is in order. In the administration of science and reading exercises, items which had been placed on audio tape were read to the respondents at the same time they followed along in their packet materials. The effect of this administrative procedure is unknown.

Table 18. Comparisons of Average Percentage Deviations from National Medians in Three Subject Areas by Six Analysis Categories [a]

| Category | | 1969-70 Science | 1970-71 Reading | 1969-70 Citizenship |
|---|---|---|---|---|
| Sex | Male | + 3.7[b] | − 2.2 | +1.2[b] |
| | Female | | | |
| Region | Northeast | + 1.8 | + 2.1 | +1.4 |
| | Southeast | − 4.9 | − 3.4 | −4.1 |
| | Central | + 1.0 | + 1.5 | +0.7 |
| | West | + 0.9 | ± 0.0 | +0.9 |
| SCO[d] | Big Cities | − 3.6 | | −1.3 |
| | Urban Fringe | + 3.0 | | +1.8 |
| | Middle Size Cities | + 0.8 | | +0.7 |
| | Smaller Places | − 1.8 | | −1.7 |
| Parental Education | 1<8th Grade | − 9.1 | −12.2 | −5.7 |
| | 2 Some High School | − 5.4 | − 4.4 | −3.0 |
| | 3 Completed High School | + 0.5 | + 1.1 | +2.3 |
| | 4<High School | + 6.1 | + 8.3 | +6.6 |
| Color | White | | + 3.2 | |
| | Black | −14.3[c] | −20.1 | −8.8[c] |
| STOC[d] | Extreme Affluent Suburbs | + 7.6 | + 7.7 | +5.0 |
| | Suburban Fringe | + 1.8 | + 2.4 | +1.1 |
| | Medium Sized Cities | + 1.1 | + 1.0 | +0.7 |
| | Inner City Fringe | − 2.2 | + 0.8 | −0.5 |
| | Small City | − 0.7 | − 0.7 | −1.0 |
| | Extreme Rural | − 5.1 | − 5.0 | −4.3 |
| | Extreme Inner City | −11.6 | −17.1 | −6.1 |

[a] Figures are averages of national medians for all age levels

[b] Shows male advantage over females

[c] Shows Black deviation from national average

[d] Size of community; size and type of community

To further document the general similarities discerned in the results of the surveys conducted to date, Table 18 shows the comparisons of average percentage deviations from the national medians in science, reading, and citizenship. With only two exceptions (males vs. females in reading and inner city fringe in reading), the directions of the deviations from the national medians in all categories were identical. That is, all categories in which pupils performed better than the national median in science showed similar results in reading and citizenship. Similarly, in all categories in which pupils fell below the national median in science, they also performed below the median in reading and citizenship. In the case of reading, however, females performed better than did males, and pupils in the inner city fringe performed slightly better in reading when compared to the national median than they did in science and citizenship.

Further support for the thesis that pupils in particular categories

Table 19. Correlations of Group Comparisons in Science Assessment to Group Comparisons in Other Subjects

| Group | Writing | Citizenship | Reading | Literature |
|---|---|---|---|---|
| Age (9<13<17>Adult) | + | + | —— | + |
| Region (SE low others close) | + | + | + | + |
| Sex (Males higher) | − | + | − | − |
| Black/Non-Black (Non-Black higher) | —— | + | + | + |
| STOC | + | + | + | + |
| Parents' Education | —— | + | + | + |

+ indicates similar pattern
− indicates different pattern
—— indicates information not yet available

tend to show similar characteristics of performance in all subjects tested is illustrated in Table 19. Out of 21 comparisons made from the data currently available, 18 showed similar patterns of performance in writing, citizenship, reading, literature, and science.

### Comments

The interrelationships between science and other subjects may permit schools to improve their teaching effectiveness by capitalizing on certain synergistic effects. For example, schools might use science narrative material at the appropriate level to develop reading skills. Thus, two learnings might be gained for the price of one. At the same time, improved reading skills may produce better science learning, particularly in areas of critical analysis, reasoning, recognizing and choosing significant information from reading material, and the like. It appears that certain skills necessary for good reading are also necessary for good "sciencing."

Reading interest may increase through exposure to science narratives. The intrinsic interest and excitement of a well-written science story may encourage young readers to develop their reading competencies more rapidly than use of other less interesting material.

The correlation between science and reading results of the National Assessment surveys seems to diminish from 9- to 13- to 17-year age levels. Since the types of exercises designed for upper age levels appeared to employ higher levels of thinking, such as analysis, reasoning, and evaluation, perhaps more practice should be given to children both in reading and in science in the skills of drawing inferences, reading critically, selecting pertinent information from data, and making interpretations. Practice in these higher level thinking processes, if carried out in two or more school subjects simultaneously, might bring about the desired result of improved competencies among children at all age levels.

The similarity of assessment results in five subject areas when analyzed for the categories of sex, region, size and type of community, parental education, and color indicates a high degree of consistency that deserves further study. The interpretations given to these data may vary with the interpreter. At least some of the similarities observed in Table 17 may be due to the procedures used by NAEP, their concern for item difficulty in the trials, use of a multiple-choice format, and other factors. As additional reports summarize the results in other subjects assessed, further similarities will be looked at with interest.

From analysis of these data, it appears that education of youth in the nation displays a remarkable homogeneity among designated subject categories. Larger differences appear when socioeconomic, racial, and geographical categories are compared. The prospects of alleviating the differences across these categories present formidable challenges to educators. The National Assessment of Educational Progress represents a significant step in recognizing and identifying the problems that face professional educators today.

# APPENDIX IV

## BIBLIOGRAPHY WITH SELECTED ANNOTATIONS


"AASA Against Participation in Assessment." *Education U.S.A.* January 12, 1967. P. 115.

"AASA Confuses Assessing With Testing, Contends Ralph Tyler." *Nation's Schools* 79:43-46, March 1967.

"AASA Gets Strong Support for Its Assessment Stand; School Administrators Opinion Poll." *Nation's Schools* 79:43-46, April 1967.

"AASA Opposes National Assessment." *The Guidepost* 9:2, February 1967.

"AASA Re-Examines the Issues." *Scholastic Teacher* 90:2, March 10, 1967.

"AASA Reselutions: Tough, Clear—And Some Breaks With the Past; National Testing and Assessment." *Nation's Schools* 81:32, March 1968.

"AASA Stews Over Assessment Issue." *Nation's Schools* 79:39-42, March 1967.

"AASA to Look at Assessment." *Education U.S.A.* February 20, 1967. P. 151.

"AASA vs. National Assessment Plan." *School and Society* 95:288-289, Summer 1967.

Ahmann, J. Stanley. "The First Results." *Compact* 6:13-17, February 1972.

Ahmann makes a number of interesting comparisons between the results of the first round of testing in science, writing, and citizenship. He first explains briefly the type of testing, the type of objectives, etc., that were involved in National Assessment and then makes comparisons showing the differences in "advantages" between males and females indicating that there is a definite male advantage in terms of scores in science and a definite female advantage in scores of writing. These advantages are especially pronounced as age increases.

Alford, J. "National Assessment—Yes or No?" *Illinois Education* 56:196-197+, January 1968.

Allison, Clay. "Technical Giants of National Assessment." *Compact* 6:18-22, February 1972.

Allison gives some insight into the historical development of National Assessment as well as discussing the personalities and background of some of the individuals originally involved. Allison reports from a journalist's point of view on the entire project telling what was done in the early stages of development, how the data were analyzed after being gathered, and how the project came into being from the standpoint of personalities of the individuals involved. This article reads like the script for a television presentation on National Assessment.

American Association of School Administrators. *National Educational Assessment. Pro and Con.* Washington, American Association of School Administrators, Organization Relations Division, and Publications Division of the National Education Association. 1966.

Anderson, C. Arnold. "The National Assessment of Educational Progress: Some Technical Deficiencies." *School and Society* 95:48-50, January 1967.

Anderson's criticism of the National Assessment Program bears on the fact that NAEP does not plan to make comparisons between schools or children. He questions the suitability of the National Assessment proposal on two grounds: (1) The program would be redundant for achieving the stated purposes and (2) too timid to achieve what one may infer to be the important aim, the improvement of schools through comparative methods. He points out deficiencies of sampling, misleading analogies with economic indexes, unimaginative specification of kinds of data needed and an uninteresting design of procedures for identifying the factors underlying variations in the quality of schools. One of the main points of Anderson's complaints is that if a national testing program is to contribute to the improvement of schools, the particular firms, schools, and school systems that score higher or lower than they would be expected to score on the basis of the extra school factors must be identified. Anderson says, "Studying actual schools and communities involves dangers of political reaction to be sure, but this step is essential if a testing program is to be used to improve schools through kinds of information not now on hand." Anderson adds, "There is little point in piling up more test scores until we are ready to face the analytical tasks objectively before us."

"As the Editor Sees It." *The Social Studies* 58:142, April 1967.

"The Assessment Debate at the White House Conference." *Phi Delta Kappan* 47:17-18, September 1965. See also: *National Educational Assessment: Pro and Con.* National Education Association, Washington, D.C. 1966. Pp. 47-50.

"Assessment of Education on the Way." *Nation's Schools* 75:68, May 1965.

"Assessment Preview." *Saturday Review* 50:95, [illegible]ary 18, 1967.

"Assessment Pro and Con." *Education Digest* 32:59, [illegible] 1967.

"Assessment Stance." *Scholastic Teacher* 90:2, May 5, 196[illegible].

"Assessment Study." *Education Digest* 32:61, April 1967.

"Attempt to Block National Assessment Apparently Collapses." *Council for Basic Education Bulletin* 11:8-9, March 1967.

"The Battle Over National Assessment." *Council for Basic Education Bulletin* 11:1-7, February 1967.

Beers, J. S., and P. B. Campbell. "Quality Education Assessment Plan." *Pennsylvania School Journal* 116: 527+, May 1968.

Bell, H. H. "Federal 'Exploration': First Step to Conquest." *Ohio Schools* 43:7-8, December 1965; Reply. T. E. Wilson. *Ohio Schools* 44:15, February 1966.

Berdie, Frances S. "What Test Questions Are Likely to Offend the General Public." *Journal of Educational Measurement* 8:87-93, Summer 1971.

This research was conducted to assure that materials used in National Assessment would not be offensive to any significant proportion of the population sampled. The method used was to poll individuals actively interested in education about the offensiveness of the material. After the research was conducted, it was found that only nine out of 208 of the exercises were considered offensive. That's less than 5 percent. In some cases the offensive exercises were withheld. In other cases the wording was changed. It would be significant at this point if it had been included in the research proper to have individuals mark those exercises they considered offensive in the actual conducting of the survey. However, in view of the fact that such a small number of items would be considered offensive it is perhaps unnecessary to cross this bridge until there is actually some type of reaction.

Beymer, Lawrence. "The Pros and Cons of the National Assessment Project." *Clearing House* 40:540-543, May 1966.

Boutwell, William D. "What's Happening in Education?" *PTA Magazine* 60:8-9, April 1966.

Brademas, John. "Momentum for Assessment." *Grade Teacher* 86:16+; March 1969.

In this article, Congressman Brademas attempts to alleviate some of the fears about National Assessment, such as federal control of education, nationalized curricula, and individual comparisons between schools, that educators might have. As well, he briefly explains the procedures that National Assessment will use to gather the data. His explanations cover subject areas to be tested, types of questions, and the sampling plan.

Brain, George B. "National Assessment Moves Ahead." *Today's Education* 60:45; February 1971.

Brain gives a brief description of the program and a few examples of results now available. He explains that the program is designed to determine the knowledge, skills, attitudes and understandings of four selected age groups—children 9, 13, and 17 years of age and young adults in the 26-35 age bracket.

According to Brain, two major trends emerge from analysis of the information:

1. Children's knowledge increases with age.
2. Adults tend to forget much of what they learned in school.

Two other trends were identified: children with educated parents do best; Black students perform as well as whites on questions about science. (Editor's note: Counter to the data.)

The author feels that while the information gained from this assessment should be useful to educational decision makers, the central question must be, "To what extent are schools advancing or impeding student growth?"

———. "Some Values of Assessment." *Compact* 6:5-6; February 1972.

Brain's first paragraph makes a case for assessment based on this quote from the book of Genesis: "And God saw everything that he had made and behold it was very good." On the basis of modern-day testing and the use of semantic differential items, it would appear that when God looked at the earth it was only average, since good is usually not the highest semantic degree of excellence that one can achieve.

Brain discusses the history for evaluation in general and more specifically the history of educational evaluation in this country. He goes on to point out the difficulties in evaluation, the general public misunderstanding of what evaluation and testing is, and the progress and problems that have been made through National Assessment, plus the information that it can give us.

Brodinsky, Ben. "Ten Major Educational Events of 1968." *School Business Affairs* 35:42-44; February 1969.

Bowlesson, Derek. "Association for Supervision and Curriculum Development Says Nay to National Assessment." *Scholastic Teacher* 90:2; April 15, 1967.

Campbell, V. N., and D. G. Nichols. "National Assessment of Citizenship Education." *Social Education* 32:279-281; March 1968.

"CAPE Receives Contract." *Catholic School Journal* 68:10; September 1968.

Chauncey, Henry. "Report of the President." *Educational Testing Service Annual Report*. E-T-S, Princeton, New Jersey. 1966. Pp. 9-60.

"Committee Established to Assess Educational Attainments." *The Teachers College Journal* 37:156+; January 1966.

Conley, W. H. "Nationwide Assessment of Education." *Catholic School Journal* 65:4; November 1965.

Coogan, Sister Phillippa M. "Roundtable Review." *Research in the Teaching of English* 6:106-112; Spring 1972.

Sister Coogan attacks the National Assessment of Writing in three areas.

1. She expresses concern with the validity of the results of the Assessment, primarily because she feels that the testing situations provided for the possibility or even the probability of inaccurate data. She contends that the testing situation was unnatural to the subjects in addition to being "boring and irrelevant." In Sister Coogan's opinion too great an emphasis was placed on the end product and too little on the process.

2. She also expresses concern about the omission of personal writing from the Assessment because "it skews it almost exclusively toward external, pragmatic, non-humanizing goals."

3. Sister Coogan feels that a result of the Assessment has been that English departments all over the country on every educational level have begun establishing behavioral objectives that are often inflexible and thus detrimental to the student.

Corbin, Richard. "Poetry and Hard Fact." *College English* 27:341-346; February 1966.

"Core Committee is Appointed to Review Proposed Program for Assessing Education." *The School Administrator* 24:1; May 1967.

Crosby, Muriel. "Curriculum Control? 'We Can Get It For You Wholesale.'" *Educational Leadership* 24:119-123; November 1966.

Denemark, G. W. Letter. *Elementary English* 43:795-797; November 1966.

De Roche, Edward F. "National Assessment: The Scapegoat?" *Education* 87:391-394; March 1967.

Ebel, Robert L. "Some Measurement Problems in a National Assessment of Educational Progress." *Journal of Educational Measurement* 3:11-18; Spring 1966.

Ebel is complimentary of the Exploratory Committee; however, he suggests a different course of action which might have been advantageous. The following is a summary of Ebel's position: (1) Valid educational assessment must be based on a valid conception of the nature of educational achievement. (2) In general it is more valid to conceive of educational achievement as an acquisition of specific elements of usable knowledge than as the cultivation of general mental abilities. (3) Statements of general objectives often contribute little to the determination of test specifics that are crucial to test quality. (4) Expert advisory panels ought to spend more of their time specifying the populations of knowledge elements that the test items will sample. (5) Any complex achievement can be assessed validly by testing separately the elements of knowledge that make it possible. (6) For measuring educational achievement simple items are usually more efficient and more discriminating than complex items. (7) It is not wise to disregard more appropriate indices of discrimination in revising and selecting items.

"Executive Committee Advises Members Not to Participate in Assessment Program." *The School Administrator* 24:1+; February 1967.

Exton, Elaine. "USOE Uses Computer-Based Models to Evaluate Education." *American School Board Journal* 154:15-16, 43-44; January 1967.

"Federal Aid." *Time* 86:60-68; October 15, 1965.

Finley, C. J. "National Assessment: Spring 1968." *California Journal of Educational Research* 20:69-74; March 1969.

In this article, Dr. Finley succinctly summarizes the National Assessment program from its development through the spring of 1968. The aims and goals of National Assessment are outlined, as is the general plan proposed to achieve them. As a final note, Dr. Finley contrasts the National Assessment program with the California State Testing Program pointing out that the two programs are quite different.

Finley, Carmen. "Not Just Another Standardized Test." *Compact* 6:9-12; February 1972.

Dr. Finley explains the rationale for the development of the National Assessment instrument, explains how the exercises were written in terms of defined goals and explains the difference between a standardized testing program, which is norm-referenced, and the National Assessment, which is criterion- or goal-referenced.

Dr. Finley makes a comparison between standardized tests and National Assessment in terms of the time required for administration, the size of the group to which the exercises are administered, and the type of items in each kind of tests. The total scores and the results are also analyzed.

Fischer, John H. "The Question of Control." *Proceedings of the 1965 Invitational Conference on Testing Problems*. Educational Testing Service, Princeton, N.J. 1966. Pp. 60-69.

Fisher, William H. "National Testing: Its Correct Name." *Educational Leadership* 23:618-619; May 1966.

Footlick, J. K. "Can Johnny Really Read? A National School Study Will Try to Assess Quality." *National Observer*. July 25, 1966. Pp. 1-15.

Frymier, Jack R. "Curriculum Assessment, Problems and Possibilities." *Educational Leadership* 24:124-128; November 1966.

From a theoretical point of view, Frymier believes that every model for curriculum development includes the concept of assessment or evaluation. Two major developments have forced the concepts of assessment and evaluation into special prominence. Talk of national assessment in education, on one hand, and the requirement for evaluation built into the Elementary and Secondary Education Act program, on the other, are forcing curriculum workers to reexamine these notions as they apply to curriculum development. He indicates that problems affecting program development stem from the fact that education is a social system with a conceptual flaw. Every effective social system reflects three phases of operation which accomplish separate functions, and these functions enable the system to maintain itself in an ongoing, dynamic, improving way. Phase one includes the intellectual activities, the planning and policy making. Phase two involves the doing, accomplishing, effecting function. Phase three is the evaluating, assessing, reflecting, judgmental function. Any careful study of social systems other than education suggests that these three functions have been made relatively discrete and that they are accomplished by different groups, each one of which has power. Social systems in an open society actually depend upon the evaluative phase of the operation to assure improvement and intelligent change.

————. "National Assessment." In *Evaluation as Feedback and Guide*. Association for Supervision and Curriculum Development Yearbook 1967, Washington, D.C. Pp. 249-259.

Frymier's report describes the National Assessment Program which was originated by Ralph W. Tyler who is the Chairman of an Exploratory Committee on Assessing the Progress of Education. According to Tyler's assessment it enables those concerned to find out where they are and how far and in what direction they need to go. Tyler's views on the most frequent use of evaluation are: (1) to appraise the achievement of individual students, (2) to diagnose the learning difficulties of an individual student, (3) to appraise the educational effectiveness of a curriculum, of instructional materials and procedures, and of administrative and organizational arrangements, (4) and to assess the educational progress of large populations in order to provide the public with dependable information to help in the understanding of educational problems and needs and to guide in efforts to develop sound policy regarding education. Tyler emphasized that education is a national rather than a local problem; there must be good data available; and these data are primarily for public rather than professional use.

Gerberich, J. Raymond. "Assessment: A Forward Look." *Educational Leadership* 24:115-118; November 1966.

Goodlad, John I. "Assessment of Educational Performance." *White House Conference on Education*. Superintendent of Documents, U.S. Government Printing Office, Washington, D. C. 1965, Pp. 44-52.

Goodlad, J. I., and M. F. Klein. "What's Happening In Curriculum Development?" *Nation's Schools* 77:70-73; April 1966.

Grieder, Calvin. "Assess U.S. Education, But Don't Use Tests To Do It." *Nation's Schools* 76:8-10; November 1965.

"The Gross Educational Product: How Much Are Students Learning?" *Carnegie Quarterly* 14:1-4; Spring 1966.

Hand, Harold C. "National Assessment Viewed As the Camel's Nose." *Phi Delta Kappan* 47:8-13; September 1965.

————. "Recipe For Control by the Few." *The Educational Forum* 30:263-272; March 1966.

Higgins, Martin J., and Jack C. Merwin. "Assessing the Progress of Education—A Second Report." *Phi Delta Kappan* 48:378-380; April 1967.

————. "Assessing the Progress of Education in Music." *Music Educators Journal* 53:52-54+; April 1967.

"Hit Assessment Fears at NASSP." *Scholastic Teacher* 90:8; April 7, 1967.

Hoffman, Banesh. "National Educational Assessment: Will It Give Us a True Picture?" *NEA Journal* 55:25, 26; February 1966.

"How Much Are Students Learning?" Report by the Committee on Assessing the Progress of Education. *Education Digest* 32:22-25; November 1966.

Howe, Harold II. "A View From Afar." *American Education* 2: inside cover; September 1966.

Johnson, George H. "Making the Data Work." *Compact* 6:29-30; February 1972.

Johnson discusses some of the problems involved in putting the data that have been gathered to work, particularly in preparing and conducting state and local assessments and developing statistical approaches that are applicable to state and local assessment so that comparisons can be drawn with the National Assessment data.

————. "National Assessment: Where Is It Now?" *Educational Leadership* 29:327-328; January 1972.

As a Director of Operations for National Assessment of Educational Progress, Johnson presents a short historical overview of the program and a general description of procedures.

He points out the controversial beginnings of National Assessment and the more recent broad-based acceptance. According to Johnson, cooperation has been very encouraging, with over 90 percent of the schools drawn in the probability sample agreeing to participate.

This first assessment is referred to as a baseline assessment. Baseline assessment has been completed in the subject areas of science, writing, citizenship, reading, and literature. However, national results are available for only the first three areas. These reports, while describing accomplishments of each age group, leave interpretations and value judgments to the user.

Johnson explains that while comparisons of measures over time will not be available for a while, these initial results justify interpretation and application. To this end, the National Assessment staff is now seeking participation of qualified educational specialists.

Kelley, Earl C. "New Approaches to Educational Outcomes." *Educational Leadership* 24:112-114; November 1966.

Keppel, Francis. "Marks on the Wall." *Compact* 6:2; February 1972.

Dr. Keppel compares National Assessment to the placing of marks on a wall as a child grows and indicates that National Assessment at this point is only one mark on a wall and thhat educators should be careful in drawing conclusions from this limited amount of data.

————. "National Education Assessment: We Badly Need It." *NEA Journal* 55:24-26; February 1966.

————. "The New Partnership." *American Association of School Administrators Official Report* 1966. Pp. 76-86.

Kock, Reino. "National Assessment of Educational Progress; A Diffusion Study." *School and Society* 97:95-97; February 1969.

Koerner, James D. "Towards National Assessment of American Schools." *Times Educational Supplement* (London) 2718:2092; June 13, 1967.

————. *Who Controls American Education—A Guide for Laymen*. Beacon Press, Boston, Massachusetts. 1968.

Kraus, D. "The National Education Assessment Project." *The Science Teacher* 33:61-63; December 1966.

Kurfman, Dana. "A National Assessment of Social Studies Education." *Social Education* 31:209-211; March 1967.

Larrick, Nancy. "Are National Tests Fair?" *Parents Magazine* 41:54-56+; December 1966.

Lee, Thomas L. "National Assessment: What Will the Project Reveal?" *The Clearing House* 42:96-97; October 1967.

Lee stresses that traditional teaching is continuing in the classroom, even though thousands of innovations have been activated in all parts of the country in the last decade. The expectations of the schools today are the same as they were a generation ago. Lee seems optimistic in his belief that the National Assessment will show a very heavy concentration on academic subject matter. He points out that despite the claim of educators regarding teaching the whole child and the changing of attitudes to affect a change in behavior, no noticeable effect has been shown. The point is made that the National Assessment will indicate this change when the results are reported.

Leonard, George B. "Testing vs. Your Child." *Look* 30:63-64+; March 22, 1966.

"Let's Not Test Nationally: AASA—But Let's Assess Nationally: Keppel:" *Nation's Schools* 77:31; March 1966.

"LBJ Budget Sets Off Fund Debate for '70." *Education USA* January 20, 1969. P. 109.

Lloyd, John. "Washington Report—LBJ: $4 Billion for Education." *Scholastic Teacher* 90:5; February 17, 1967.

Mattucii, Corinne Weil. "A Program on National Testing for Your Discussion Group." *Parents Magazine* 41:12+; December 1966.

Mayer, Martin. "Stop Waiting for Miracles." *The PTA Magazine* 61:19-23; November 1966.

McLaughlin, F. C. "A National Assessment of Education." *New York State Education* 54:52-54+; March 1967.

McMorris, R. F. "National Assessment: Coming In 1968-69?" *Phi Delta Kappan* 49:599-600; June 1968.

McMorris, R. F. "Progress Toward Assessing Progress in Education." *Educational Horizons* 46:167-171; Summer 1968.

McMorris points out that the Assessment Project should help us to increase our knowledge of what people at various ages can do. This type of information should allow us to better describe our products and the progress in education. He points out the differences between the Assessment and our usual ways of testing.

Looking at these differences should assist in the understanding of both processes and in designing suitable evaluation procedures for other uses. Many educators who are subject-matter specialists have contributed to the Assessment Project. The proposed exercises have all been examined critically, and educators' comments have been considered by the organizations responsible for writing the exercises. Revisions are also being made. A great deal of preliminary planning has already been done to estimate how best to sample the population at each of the four levels.

Mellon, John C. "A Review By a Specialist on the Acquisition of the Various Competencies Underlying Language Performance—Roundtable Review." *Research in the Teaching of English* 6:86-106; Spring 1972.

Mellon is extremely critical of the National Assessment writing results. He questions the results on both empirical and philosophical grounds. He makes six suggestions that summarize his criticisms and at the same time help to rectify the weaknesses that he perceives in the First Writing Assessment. Brief descriptions of these suggestions are:

1. The exercises should be constructed so that the subjects feel they are performing real writing tasks.

2. The exercises and composition topics should be designed from a developmental perspective. Particular attention should be paid to egocentrism, rhetorical distance, and abstractive attitude.

3. Techniques for objectively characterizing vocabulary, syntactic fluency, clarity, stylistic virtuosity, organizational sense should be developed. Descriptive analyses of writing should also be conducted.

4. Absolute descriptive measures should be developed in the evaluation of composition.

5. More consideration must be given to ways of evaluating creative writing or personal writing. The assessors should consider the possibility of looking at writing done outside the examination room.

6. The assessment of writing appreciation needs to be reconsidered. "If writing appreciation is to be appraised, imaginative spectator writing must be examined, for that is the essential genre of writing as writing."

Merwin, Jack C. "National Evaluation of Educational Progress Underway." *AERA Newsletter*, October 1965. P. 3.

———. "The Progress of Exploration Toward a National Assessment of Educational Progress." *Journal of Educational Measurement* 3:5-10; Spring 1966.

The charge given to the Exploratory Committee on Assessing the Progress of Education was to confer with teachers, administrators, school board members, and others concerned with education to get advice on the way in which a national assessment of educational progress could be designed to be constructively helpful to the schools. From these conferences came the following recommendations: (1) The assessment should be developed in cooperation with teachers and tried out in the school. (2) The initial effort should include more than the three R's. (3) The assessment should be under the direction of a private commission and not be a project of federal or state governments.

*Age Levels:* (1) Age levels 9, 13, 17, and adult were chosen for the samples. Age 9 was included because by this age children might be expected to have achieved some goals of primary education. By age 13 there should be substantial progress in attaining the goals of elementary education. Seventeen-year-olds are normally high school seniors. Adults were included to provide a look at elementary and secondary education as well as a means of identifying areas where there may be a general continuation of development. (2) At each age level three descriptions should be sought. Identify behaviors that 90%, 50%, and 10% of the age group can exhibit. (3) The instruments and procedures should be aimed at descriptions of what large groups can do. (4) The objectives should be considered authentic by scholars, be goals the schools are trying to achieve, be considered by thoughtful laymen as things desirable for American youth to learn. (5) Every exercise used must sample an objective set forth for the project and be meaningful to thoughtful laymen.

Merwin, Jack C., and Frank B. Womer. "Evaluation in Assessing the Progress of Education to Provide Bases of Public Understanding and Public Policy." In *Educational Evaluation: New Roles, New Means:* The Sixty-Eighth Yearbook of the National Society for the Study of Education, Ralph W. Tyler, Ed. The National Society for the Study of Education, Chicago, Illinois. 1969. Pp. 305-334.

Merwin, Jack C., and M. J. Higgins. "Assessing the Progress of Education in Mathematics." *The Mathematics Teacher* 61:130-135; February 1968.

Merwin, Jack C., and Ralph W. Tyler. "What the Assessment of Education Will Ask." *Nation's Schools* 78:77-79; November 1966.

Meyer, Agnes E. *National Assessment of Education: What We Don't Know Can Hurt Us.* Report for the National Committee for the Support of the Public Schools. Washington, D.C. May 1967.

Moellenberg, Wayne P. "National Assessment: Are We Ready?" *The Clearing House* 43:451-454; April 1969.

Moellenberg feels that decisions about National Assessment are being made by board members and legislators while educators are still in the exploratory phase of the issue. To avoid this "decision of default" educators must become involved. The article depicts: (1) The need for local level assessment and the development of local norms. (2) The rapid pressure building due to the demands for better evaluation on a broader scale. (3) The instruments for broad scale evaluation process create such heavy demands that it would be necessary to entrust outside operations by organizations with extensive resources. (4) The demands of the public for educators to show results at a given place. (5) The special preparation which will be needed by teachers, administrators, school board members, legislators, and parents to facilitate appropriate use of tests and their results. The analysis of these factors shows that if considerations can demonstrate the advisability of assessment as it has been proposed, it can be chosen with reason. If not, alternative modes of evaluation could be devised in time to be substituted. Moellenberg also focused on the possibility of diverting educators' interests and efforts from children to tests.

Mood, A. M. "National Assessment." *American Education* 3:11-12; April 1967.

Mood's article gives a positive view to the proposed National Assessment Program. He has asked many questions, most of which do not have immediate answers but which the National Assessment Program could provide answers in time. Such questions as: How many high school students of average ability or better drop out before graduation? Why y do they drop out? What is the effectiveness of this or that program for keeping students in school? What is the cost of these programs for preventing dropouts? What we don't know but we ought to know if we are to develop our budget sensibly. Another question he asks is, "Given school systems of equal quality, do minority children learn more in integrated schools or segregated schools? How about majority children? How much more or less do they learn in this or that subject?" Other questions are: "Do young children learn better in classes with their friends in neighborhood schools or do they learn better if close friends are not in the same class?" "Do today's high school graduates know more than those of three years ago? Is their vocabulary larger or smaller? Do they have a better or poorer understanding of private enterprise, of government, of diet and health, of the psychology of family stability, of the upbringing of infants, of the rights and responsibilities of a productive citizen, of the relevance of history to the international tensions of today, of the physical universe? We haven't the slightest notion." The

article by Mr. Mood is a thoughtful consideration of many of the potential values of the National Assessment Program.

Morris, Lewis H. "Countdown: National Assessment of Educational Progress." *Oklahoma Teacher* 50:23-25; January 1969.

Morrisett, Lloyd N. "Educational Assessment and the Junior College." *Junior College Journal* 37:12-14; March 1967.

"NEA Resolutions—1968: National Assessment of Educational Progress." *Today's Education* 57:68; September 1968.

"NSTA Position on Critical Issues Confronting the Science Teaching Profession: National Assessment." *The Science Teacher* 35:44; November 1968.

"National Assessment." *Education Digest* 34:59; January 1969.

"National Assessment." *Quest* 2:6; January 1969.

"National Assessment." *School Management* 13:40; January 1969.

"National Assessment Almost Here." *Education USA* May 20, 1968. P. 211.

"National Assessment and Educational Aims." *Association for Supervision and Curriculum Development News Exchange* 9:2; March 1967.

"National Assessment Draws Near: Its Testing Aspects Are Attacked." *Nation's Schools* 76:22; October 1965.

"National Assessment Headquarters Moves to Michigan." *Quest* 2:5; Fall 1968.

"National Assessment Launched." *Saturday Review* 51:108-110; November 16, 1968.

"National Assessment: National Controversy." *Scholastic Teacher* 90:2; February 3, 1967.

"A National Assessment of Education: The Shape of Education for 1966-67." *Education USA* 1966. Pp. 16-19.

"National Assessment of Education Next Fall." *Education USA* October 27, 1966. P. 49.

National Assessment of Educational Progress, *Report 1, 1969-1970 Science: National Results and Illustrations of Group Comparisons*. Education Commission of the States, Denver, Colorado, July 1970. (For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Price $1.75.)

*National Assessment of Educational Progress, Report 1—Science: National Results, Observations and Commentary of a Panel of Reviewers*. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. July 1970.

Presented are five reviews of the National Assessment of Educational Progress results in science. Dr. Mildred Ballou discusses the objectives of the assessment by age level with concern over explanations for responses, social implications, and validity of testing exercises.

*National Assessment of Educational Progress, Some Questions and Comments*. National Education Association of the United States—Department of Elementary School Principals, Washington, D.C. 1967.

"National Assessment Program Spotlighted in General Sessions of AASA Convention." *The School Administrator* 23:3-5; March 15, 1966.

"National Assessment Progress." *Education Digest* 32:60-61; December 1966.

"National Assessment: Ready Or Not, Here It Comes." *Council for Basic Education Bulletin* 10:1-3; March 1966.

"National Assessment: Stop and Look." *AASA Convention Reporter*, February 16, 1967. P. 10.

"National Assessment Underway." *The Instructor* 78:6; January 1969.

"The National Education Assessment Project." *The Science Teacher* 33:61-63; December 1966.

"National Testing Program Would Be Tragic, Connor Says." *The School Administrator* 23:3; November 1965.

"Nationalized Testing? 'We'd Welcome It', Say Six Out of Ten Polled." *Nation's Schools* 75:40; June 1965.

Norris, Eleanor L. "What We Are Learning from the National Assessment." *American Education* 7:18-23; July 1971.

Norris contends that a great deal of valuable information has resulted from the research carried on by NAEP. National Assessment not only provides data concerning educational levels of different age groups but also provides data related to geographical region, size of community, and sex. Further reports will give data for color (Black, white, total), educational environment in the home, and type of community. The results of the assessment so far can provide much information about education in general and can be of use to classroom teachers and curriculum planners. In addition to these specific results other materials are available that describe the educational objectives of National Assessment. Educators interested in establishing objectives for classrooms and schools would profit from a study of these objectives.

———. Editor. *Science Objectives*. Committee on Assessing the Progress of Education, Ann Arbor, Michigan. 1969.

The general procedures used to develop educational objectives for the National Assessment of Educational Progress are outlined, as are the procedures used to develop science objectives. Four primary objectives of science education are stated: (1) know fundamental facts and principles of science, (2) possess the abilities and skills needed to engage in the processes of science, (3) understand the investigative nature of science, and (4) have attitudes about and appreciations of scientists, science, and the consequences of science that stem from adequate understandings. Each primary objective is divided into subobjectives. Behaviors typical of four chosen ages—9-, 13-, and 17-year-olds and adults—are delineated for many of the subobjectives. Appendices list the names of scientists, of lay panel chairmen, and of educational organizations involved in developing the objectives.

"Organizations on Assessment." *Phi Delta Kappan* 48:392; April 1967.

"Plans for Educational Assessment Revealed." *Behavioral Sciences Newsletter* 5:25; December 30, 1968.

"The Price of Admission: Assessment and Red Tape." *Education USA* November 18, 1965. P. 45.

"The Problem of National Standards." *Education and Social Changes*. NCSPS, Washington, D.C. 1966.

"A Program of National Assessment." *American Association of School Administrators Official Report* 1966. Pp. 5-30.

"Quiz for a Nation." *Current Science* (Teacher's Edition) 53:2; September 20, 1967.

"Resistance Against 'Assessment' Eases." *Education USA* November 4, 1968. P. 55.

Rice, Arthur H. "Let States and Cities Decide What To Measure." *Nation's Schools* 78:8-10; July 1966.

Saylor, Galen. "National Assessment: Current Status." In *Humanizing Education: The Person in the Process*, R. Leeper, Editor. Association for Supervision and Curriculum Development, Washington, D.C. 1967. Pp. 104-114.

"School Administrators Plan Review Commission to Examine National Assessment of Education." *NEA Reporter*, February 24, 1967. P. 7.

Sica, M. G. "The Project to Assess Educational Progress in America: A Report of Progress and Reaction." *California Social Science Review* 6:22-26; December 1966.

Sizer, Theodore R. "Pressing Problems and National Assessment." *The PTA Magazine* 60:18-22; November 1966.

———. "Pressing Problems in Education: A National System of Schools." Speech given at National PTA Convention. Baltimore, Maryland, May 17, 1966.

"Sleeping Giant Awakens." *American School Board Journal* 156:4; September 1968.

"Slight Delay." *American School Board Journal* 156:4; December 1968.

Slotnick, Henry B. "A Response from the Assistant to the Director of Research and Analysis, National Assessment—Roundtable Review." *Research in the Teaching of English* 6:112-121; Spring 1972.

Slotnick responds to both Sister Coogan's and Mellon's criticisms of the National Assessment of Writing. He attacks Sister Coogan's assertion that the National Assessment uses behavioral objectives by stating that National Assessment has never advocated the use of behavioral objectives

and that there has been no mention of behavioral objectives in any of the writing reports.

Slotnick answers Sister Coogan's argument faulting National Assessment for not reflecting current thinking on the writing of children by saying that it was not included due to shifting priorities in the English profession, a phenomenon for which National Assessment can't be blamed.

In response to the charge that the tests were boring and irrelevant, Slotnick cites evidence that refutes Sister Coogan's assertion.

To answer Mellon, Slotnick considers Mellon's six suggestions since they summarize his opinions concering National Assessment of Writing. Much of Slotnick's rebuttal further clarifies the aims of National Assessment but also acknowledges the validity of Mellon's arguments by saying that much of what he has suggested soon will be or, in fact, is now taking place in National Assessment.

Stevens, Troxel. "National Assessment: Vital Need or Dirty Word?" *Texas Outlook* 53:20-21; April 1969.

After five years of preparation, the project of National Assessment will begin a three-year cycle. Americans will be tested at different stages in life to determine their knowledge, skills, and attitudes about a variety of things. Later tests will determine how much progress has been made in education. The stifling question is who will govern the assessment.

The need for National Assessment grew out of the debate over the 1965 Elementary and Secondary Education Act. Congress and citizens wanted to know what they were buying with their monies. Stevens believes that a meaningful program in education can be accomplished only by an organization or agency because of the high demands for competence and objectivity in the operation.

There are fears that national testing will measure all students by single standards and of the publicity which will be attached to the program. Furthermore, there is no certainty that National Assessment will work nor provide the data which the public demands.

"Teacher Opinion Poll: National Testing." *Today's Education* 56:6; September 1967.

"Tempers Flare on Testing." *Instructor* 76:4; March 1967.

"Tester Tyler and the Skeptics." *AASA Conference Reporter*, February 16, 1966. Pp. 6-7.

"Testing: Toward National Assessment." *Time* 89:61; January 27, 1967.

"Toward a National Assessment of Education." *Education USA*, September 30, 1965. P. 17.

Turney, D., and B. E. Altman. "National Assessment: Why All the Fuss?" *Educational Leadership* 23:442-446; March 1966.

"Two Steps Forward." *Saturday Review* 50:76; April 15, 1967.

Tyler, Ralph W. "Assessing the Progress of Education." *Phi Delta Kappan* 47:13-16; September 1965.

———. "Assessing the Progress of Education." *Science Education* 50:239-242; April 1966.

———. "Assessing the Progress of Education in Science." *The Science Teacher* 33:11-14; September 1966.

This article by Tyler directs its attention to some of the special expectations of the National Assessment Project in the area of science. Tyler points out that two traditional uses of evaluation are not to be used in this assessment project. It is not intended to appraise the achievement of individual students. Neither is it to be used to diagnose the difficulties of an individual student or of an entire class. Likewise, the assessment is not intended to appraise the educational effectiveness of a curriculum, of a course of instructional materials and procedures, or of administrative and organizational arrangement. The intent of the National Assessment Project is to furnish overall information about the educational attainments of large numbers of people. A sampling procedure will be used in which the educational levels of four age groups—9-, 13- and 17-year-olds, and adults will be assessed.

Tyler lists the types of people who will formulate statements of objectives. Among them are science teachers, curriculum specialists, and scientists. The four major objectives of science education as stated, delineated, and exemplified in the report of the panel mentioned above are (1) know the fundamental facts and principles of science, (2) possess the abilities and skills needed to engage in the processes of science, (3) understand the investigative nature of science, (4) have attitudes about and appreciation of scientists, science, and the consequences of science that stem from adequate understanding.

In addition to the overall assessment of national objectives, Tyler points out that subgroupings of data will be made in order to gather information about populations within the total country which vary among themselves and present different degrees and kinds of progress and different problems to be solved. Tyler says, "The particular populations that need to be treated separately may change over the years ahead but for some time age, sex, socioeconomic status, geographic location, and rural, urban, and suburban differences will probably be significant. Hence, the present plan is to assess a probability sample for each of 192 populations defined by the following subdivisions: boys and girls, four geographic regions, four age groups (9, 13, 17, and adult), three divisions by urban, suburban, rural classifications, and two socioeconomic levels."

Results will be reported by percent of individuals within various groups who perform successfully on the exercises of the National Assessment Program.

———. "The Current Status of the Project on Assessing the Progress of Education." *Educational Horizons* 45:184-190; Summer 1967.

———. "The Development of Instruments For Assessing Educational Progress." *Proceedings of the 1965 Invitational Conference on Testing Problems*. Educational Testing Service, Princeton, New Jersey. 1966. Pp. 95-105.

———. "First Reports from the National Assessment." *Educational Leadership* 28:577-580; March 1971.

Tyler emphasizes that National Assessment offers a procedure for curriculum evaluation that currently used achievement tests have not offered. National Assessment represents what is being learned by all children. Test writers encountered difficulty in designing instruments for National Assessment because those that have been constructed before were designed to measure individual difference and place students on a continuum from high to low. A number of generalizations have emerged from current report on National Assessment. These results enable curriculum majors to discuss important problems objectively against the background of data from the entire nation. National Assessment is providing the lay public, teachers, and the curriculum worker with dependable data about what children have learned. Teachers, administrators, and other school personnel are now cooperating in the National Assessment effort.

———. "Let's Clear the Air on Assessing Education." *Nation's Schools* 77:68-70; February 1966.

———. "National Assessment of Educational Progress." *Art Education* 20 special issue: 15-17; September 1967.

———. "The Objectives and Plan for a National Assessment of Educational Progress." *Journal of Educational Measurement* 3:1-14; Spring 1966.

———. "A Program of National Assessment." *The Educational Forum* 30:391-396; May 1966.

———. "Why Evaluate Education?" *Compact* 6:3-4; February 1972.

Tyler makes comparisons between the National Census and National Assessment. He also compares census data on health, welfare, etc., to the desirability for information of this type in education. He points out that the results of National Assessment are not reported in individual scores but are reported in terms of students' responses to individual test items. Tyler further relates National Assessment to educational accountability and discusses implications for using National Assessment as an accountability instrument.

Von Ende, Zoe. "Layman's View." *Compact* 6:23; February 1972.

Von Ende discusses National Assessment from a layman's point of view and gives impressions about its strength and weaknesses as she perceives them.

One point, which is particularly salient, is that the results of National Assessment may well be used to change curricula or subject matter and yet with no change in the method of teaching the material, or change in teachers, very little will be expected in the way of results. She also discusses the type of publicity that should be given to National Assessment in order to insure that it is properly understood by the general public.

Wolfe, John K. "Industry—An Unnoticed Consumer." *Compact* 6:7-8; February 1972.

Wolfe makes a case for National Assessment on the basis that industry could use the results to make a determination as to where they might locate industrial plants, and businesses on the basis of the level of education.

This appears to be an oversimplification of the type of data that might go into a business's data banks once a decision is made to construct or locate a new plant. This is not to say that the educational level of individuals in an area does not have an influence on industry but it is doubtful if the results of National Assessment on the basis of a sample assessment alone is sufficient justification for this type of reasoning.

He goes further to say that it will have an influence on what type of approach to use in advertising in order to communicate effectively with the general public. The low level of television commercials today which are estimated to be about the 4th grade level if influenced by the results of National Assessment in science would lower this even further.

All in all, Wolfe's case for the uses of National Assessment by industry appears to be very weak, at least on the basis of using the results from the initial testing.

Womer, Frank B. *What is National Assessment?* National Assessment of Educational Progress, Ann Arbor, Mich., 1970.

The title is an accurate description of the contents of this pamphlet. Womer gives a complete description of the entire process of developing the objectives, testing, sample size, etc. However, there is not enough information to make a decision as to whether or not the exercises do, in fact, have face validity and either external or internal validity let alone reliability. This description of National Assessment is quite suitable for the lay person in finding out what is being done. It is also suitable for general educational needs in arriving at some superficial decisions. A number of questions arise that the discussion does not answer. The question arises as to whether or not a typical standardized test that is designed to discriminate between levels of achievement of individuals would not be as useful a measure as the degree of performance of groups with simply a different treatment of data. Content validity, as the only measure as to whether or not a particular exercise meets the required criteria, does not seem appropriate. It would appear that questions, after careful review by experts for content validity, should be checked against other measures of the same content and correlations drawn as a verification of content validity.

The statement that exercises were specifically developed and verified for use in this test is not acceptable on face value since it is generally known that the contracting agency attempted, wherever possible, to utilize material from its boneyard of questions which were either rejects or were modifications of questions already used in national standardized tests.

In the case of out-of-school sampling, information is not initially given on the percent of individuals who did accept the proposal to take the examination. Information is not given as to what the results or even if an item analysis was conducted on the exercises after the tests had been used at least once. The degree of difficulty of particular items apparently has not been computed. At any rate, that information is not given. These are, perhaps, minor criticisms of this otherwise excellent description and should not be meant to detract from the total idea—one assessment that might be given consideration in further examination of the process.

The major strength in the description of how the objectives were arrived at seems to evolve around the statement that the objectives are considered tentative or perhaps considered a working instrument to be used in a continual revision of the science exercises. The objectives, themselves, taken on face value seem to be quite well done, as described in this publication. A number of questions do arise, however, that are not answered in describing the objectives themselves, or the procedures developing these objectives. The statement is made that professionals and laymen were involved in the development of these objectives and that they formulated statements of objectives to meet the two essential criteria. However, the procedure for formulating the objectives is not described. It seems questionable on face value to simply sit down in a committee and formulate them. Perhaps reviews of value banks or the development and accumulation of the banks or even the use of value banks as developed in prior years by the United Nations would serve as a better basis for developing objectives. Every objective was to meet three criteria: (1) considered important by scholars; (2) accepted as an educational task by the school; (3) considered desirable by thoughtful lay citizens.

It would appear that two important components are neglected. First, the objective element to our overall objective or goals in education, itself. Second, why were not students' needs considered the prime criteria for the development of objectives? In which case, not only a value bank but a student need bank would have been useful tools in developing these objectives. The objectives were evaluated, once formulated, by scholars and lay people, but students, themselves, had no input.

Furthermore, it would appear that objectives should be of a hierarchical nature even though all steps of a hierarchy of development could not be measured. In the case where sampling was done at various age levels, it would appear that a hierarchical series of objectives would be much easier to prepare exercises for. It seems quite evident that there is a big discrepancy between what is expected for 17-year-olds but not expected of adults. If, indeed, education is a lifetime process you would expect to see some improvement or at least some change in a positive direction in the 17-year-olds and the adults rather than the opposite as expected in the objectives.

There is a question as to whether the objectives, especially for very young students of age 9, are consistent with modern learning theories or with Piaget's findings in development of mental tasks. Some subobjectives are extremely vague and do not define in an acceptable manner exactly what is expected at a particular age nor a level of performance of individuals at that age.

Womer, Frank B., and Marjorie M. Mastie. "Can National Assessment Change American Education?" *Compact* 6:26-28; February 1972.

This article points out that the results of National Assessment, like the results from any survey or census type statistic, can be useful to decision makers in arriving at decisions consistent with the facts. It further points out that National Assessment has served as a stimuli in the movement towards accountability and has also made contributions to measurement methodology.

As soon as the results from all areas have been completely analyzed there will be a basis for curriculum planners to properly allocate time to the areas most in need of emphasis. The number of applications or possible applications of results of National Assessment are discussed, not only from the standpoint of curriculum revision but from the standpoint of school finance, education, known political needs of the states, levels of responses to geographical or racial differences, plus many others.

While the authors state that these are pure speculations, they are speculations that illustrate innumerable areas in which National Assessment results may prove to have considerable utility.

Again, the emphasis is made, as many writers have stated, that this is only a beginning or the first dot or mark on the wall (Keppel) in attempting to analyze what has happened and how it is happening in American education.

———. "How Will National Assessment Change American Education?" *Phi Delta Kappan* 53:118-120; October 1971.

In this article, Womer, the first staff director of NAEP, discusses the utility of results of the National Assessment Program. He explains that utility is a difficult question to answer because the program is designed to provide general information. It is not designed to produce answers to specific educational questions. He suggests that the National Assessment Program should be part of a larger information-gathering project. State, local, and special research studies are not needed to complete the picture.

The program is not investigating specific hypotheses about cause and effect; rather it is interested in supplying facts then letting others determine how and why.

The writers believe that the role of National Assessment should not be limited to information production. They believe that although it should not prescribe remedies, it should act as a catalyst, seeing that implementation does take place.

### *Additional References*


Guthrie, James W., and Edward Wynne, Editors. *New Models for American Education*. Prentice Hall, Englewood Cliffs, New Jersey. 1971.

Mosier, Charles I. "A Critical Examination of the Concepts of Face Validity." *Educational and Psychological Measurement* 7:191-205; Spring 1947.

*The Shape of Education for 1971-72*. National School Public Relations Association. Washington, D.C. 1971.

# APPENDIX V
# RELEASED ITEMS FROM THE 1969-70 SCIENCE ASSESSMENT

## RELEASED EXERCISES—Age 9

### OBJECTIVE I: Know the Fundamental Facts and Principles of Science

EXERCISE 101

(9: 5-13) (overlaps Exercise 201)

Where does a human baby come from?

| Age 9 | | |
|---|---|---|
| 1 % | O | The stork brings the baby. |
| 92 | ● | The baby comes from its mother's body. |
| 3 | O | The doctor gives the baby to the mother. |
| 1 | O | The father buys the baby for the mother. |
| 2 | O | The hospital keeps many babies and the mother picks one out. |
| 1 | O | I don't know. |
| 1 | | No response |
| 101 % | | |

Not administered to the in-school sample in one Southeastern county and one Southeastern city at the request of state or local authorities.

EXERCISE 102

(9: 1-6)

If you want to burn a stick, you should

| Age 9 | | |
|---|---|---|
| 2 % | O | wet it. |
| 1 | O | float it in a pond. |
| 92 | ● | see that it is dry. |
| 4 | O | cover it with dirt. |
| 1 | O | I don't know. |
| 0 | | No response |
| 100 % | | |

EXERCISE 103

(9: 5-6) (overlaps Exercise 202)

For which of the following reasons should you brush your teeth?

| Age 9 | | |
|---|---|---|
| 2 % | O | To straighten your teeth |
| 2 | O | To make your teeth harder |
| 1 | O | To make your teeth sharper |
| 2 | O | To help your teeth grow larger |
| 91 | ● | To help keep your teeth from decaying |
| 1 | O | I don't know. |
| 0 | | No response |
| 99 % | | |

EXERCISE 104

(9: 6-13)

All of the following can be burned in a fireplace EXCEPT

| Age 9 | | |
|---|---|---|
| 89% | ● | iron. |
| 2 | O | leaves. |
| 2 | O | paper. |
| 6 | O | wood. |
| 0 | O | I don't know. |
| 1 | | No response |
| 100 % | | |

EXERCISE 105

(9: 8-15)

Bees go to flowers in order to

| Age 9 | | |
|---|---|---|
| 3 % | O | see the flowers. |
| 6 | O | smell the flowers. |
| 88 | ● | get nectar for food. |
| 2 | O | hide from the wind and rain. |
| 1 | O | I don't know. |
| 0 | | No response |
| 100 % | | |

EXERCISE 106

(9: 8-10) (similar to Exercise 203)

On a summer day, which of the following clouds is most likely to bring rain?

| Age 9 | | |
|---|---|---|
| 2 % | O | Thin fluffy clouds |
| 2 | O | Red clouds at sunset |
| 87 | ● | Thick dark-gray clouds |
| 7 | O | Clouds that look like white sheep |
| 2 | O | I don't know. |
| 0 | | No response |
| 100 % | | |

## EXERCISE 107

(9: 8-6)

The surest way to put out a fire of wood sticks is to

| Age 9 | | |
|---|---|---|
| 4 % | O | fan the fire. |
| 87 | ● | soak the wood with water. |
| 4 | O | put some dry grass on the fire. |
| 3 | O | put some smaller sticks on the fire. |
| 2 | O | I don't know. |
| 0 | | No response |
| 100 % | | |

## EXERCISE 108

(9: 2-2)

Which of the following is most important in building muscle?

| Age 9 | | |
|---|---|---|
| 4 % | O | Fat |
| 85 | ● | Protein |
| 2 | O | Salt |
| 2 | O | Starch |
| 2 | O | Sugar |
| 6 | O | I don't know. |
| 0 | | No response |
| 101 % | | |

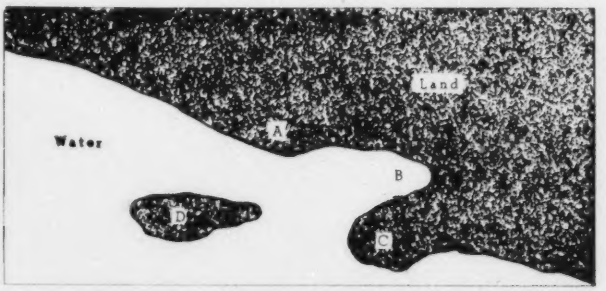
## EXERCISE 109

(9: 1-6)

Nearly all rocks on the Earth's surface are

| Age 9 | | |
|---|---|---|
| 5% | O | gas. |
| 6 | O | liquid. |
| 84 | ● | solid. |
| 4 | O | I don't know. |
| 0 | | No response |
| 99 % | | |

## EXERCISE 110




(9: 7-2)

Which of the letters on the map above is on an island?

| Age 9 | | |
|---|---|---|
| 7% | O | A |
| 4 | O | B |
| 1 | O | C |
| 83 | ● | D |
| 3 | O | I don't know. |
| 2 | | No response |
| 100 % | | |

## EXERCISE 111

(9: 7-9)

One reason that there is day and night on Earth is that the

| Age 9 | | |
|---|---|---|
| 8 % | O | Sun turns. |
| 4 | O | Moon turns. |
| 81 | ● | Earth turns. |
| 6 | O | Sun gets dark at night. |
| 1 | O | I don't know. |
| 0 | | No response |
| 100 % | | |

## EXERCISE 112

(9: 3-11)

If you see a bottle labeled ACID, you should

| Age 9 | | |
|---|---|---|
| 1 % | O | add soap to it. |
| 3 | O | put it in a box. |
| 80 | ● | be careful with it. |
| 3 | O | put it under water. |
| 10 | O | pour it down the sink. |
| 2 | O | I don't know. |
| 0 | | No response |
| 99 % | | |

EXERCISE 113

(9: 7-8)

Which of these trees stays green in the United States during the winter?

| Age 9 | | |
|---|---|---|
| 4% | O | Apple |
| 7 | O | Elm |
| 6 | O | Maple |
| 80 | ● | Pine |
| 4 | O | I don't know. |
| 0 | | No response |
| 101% | | |

EXERCISE 114

(9: 4-13)

One is most likely to find an alligator in

| Age 9 | | |
|---|---|---|
| 79% | ● | a swamp. |
| 3 | O | the woods. |
| 3 | O | the desert. |
| 13 | O | a cold lake. |
| 1 | O | I don't know. |
| 0 | | No response |
| 99% | | |

EXERCISE 115

(9: 6-12)

For you to see something, what must reach your eyes?

| Age 9 | | |
|---|---|---|
| 79% | ● | Light |
| 3 | O | Smoke |
| 3 | O | Sound |
| 13 | O | Nothing |
| 2 | O | I don't know. |
| 1 | | No response |
| 101% | | |

EXERCISE 116

(9: 3-7)

Which of these plants does NOT have green leaves?

| Age 9 | | |
|---|---|---|
| 9% | O | A dandelion |
| 7 | O | Grass |
| 77 | ● | A mushroom |
| 5 | O | A willow tree |
| 2 | O | I don't know. |
| 1 | | No response |
| 101% | | |

EXERCISE 117

(9: 5-2)

If a lid is put on a jar in which a candle is burning, what happens?

| Age 9 | | |
|---|---|---|
| 3% | O | The candle breaks. |
| 1 | O | The candle gets longer. |
| 16 | O | The candle burns faster. |
| 75 | ● | The candle flame goes out. |
| 4 | O | I don't know. |
| 0 | | No response |
| 99% | | |

EXERCISE 118

(9: 10-22)

How do some animals hide from other animals?

_____

_____

_____

_____

_____

_____

| Points | Percentage Receiving X Points |
|---|---|
| 1 | 18 |
| 2 | 23 |
| 3 | 29 |
| 4 | 17 |
| 5 or more | 5 |
| No response | 7 |
| | 99% |

To be counted as responding successfully, a student must have received at least 2 points.

% successful 74%

(continued on next page)

ACISE 118
(Continued)

(9: 10-22)

Points were given according to the method below:

2 points for mentioning protective coloration

2 points for mentioning "protective shapes," including behavior such as that of an opossum

4 points for mentioning locations for hiding

(a point each for any 4 reasonable ones)

(1 point for location regardless of adjective preceding it)

(1 point for "getting behind something" if this appears alone)

(1 point for a given location regardless of preposition preceding location; e.g.,

in bush
behind bush
under bush
beside bush

is given one point in total

trees
woods
bushes
shrubs

would each get one point even though similar

1 point for "flight" regardless of term or terms such as "running, flying, leaping, swimming" used

No points for: "killing other animals"

No extra points for examples of animals that hide in a certain way

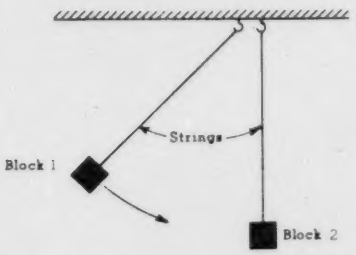
EXERCISE 119

(9: 1-15)

Which of these tasks would take the most work?

| Age 9 | | |
|---|---|---|
| 3 % | O | Lifting a 10-pound weight 1 foot |
| 15 | O | Lifting a 20-pound weight 1 foot |
| 4 | O | Lifting a 10-pound weight 2 feet |
| 73 | ● | Lifting a 20-pound weight 2 feet |
| 4 | O | I don't know. |
| 0 | | No response |
| 99 % | | |

EXERCISE 120




(9: 8-11)

When Block 1 swings down and hits Block 2, which of the following will most likely happen?

| Age 9 | | |
|---|---|---|
| 3 % | O | Block 2 will not move at all. |
| 18 | O | Block 2 will swing off to the left. |
| 70 | ● | Block 2 will swing off to the right. |
| 4 | O | The string holding Block 2 will break. |
| 4 | O | I don't know. |
| 0 | | No response |
| 99% | | |

EXERCISE 121

(9: 1-10)

You can see the Sun only in the daytime because

| Age 9 | | |
|---|---|---|
| 70 % | ● | the Earth is turning. |
| 3 | O | people sleep at night. |
| 3 | O | there are more clouds at night. |
| 22 | O | the Sun shines only part of the time. |
| 2 | O | I don't know. |
| 0 | | No response |
| 100 % | | |

EXERCISE 122

(9: 1-8)

Which of the following insects are most helpful to man?

| Age 9 | | |
|---|---|---|
| 69% | ● | Honeybees |
| 8 | O | Lice |
| 7 | O | Locusts |
| 7 | O | Termites |
| 9 | O | I don't know. |
| 0 | | No response |
| 100 % | | |

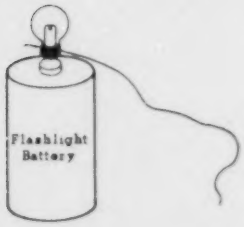
EXERCISE 123

(9: 3-15)

What can scientists learn by studying some fossils?

| Age 9 | | |
|---|---|---|
| 9% | O | Why earthquakes took place |
| 62 | ● | What animals lived long ago |
| 14 | O | How far the Moon is from Earth |
| 8 | O | What the weather will be tomorrow |
| 7 | O | I don't know. |
| 0 | | No response |
| 100 % | | |

EXERCISE 124




(9: 6-15)

Jane wrapped the end of a piece of wire around the base of a flashlight bulb. When she touched the bottom of the bulb to the center of the top of a new battery, the bulb did not light. What should Jane do next to light the bulb?

| Age 9 | | |
|---|---|---|
| 13% | ○ | Touch the end of the wire to the bulb. |
| 4 | ○ | Put the end of the wire in a drop of water. |
| 11 | ○ | Touch the bulb to the bottom of the battery. |
| 61 | ● | Touch the end of the wire to the bottom of the battery. |
| 10 | ○ | I don't know. |
| 1 | | No response |
| 100% | | |

EXERCISE 125

(9: 6-14)

Most land plants get most of their water directly from which of the following?

| Age 9 | | |
|---|---|---|
| 2% | ○ | Animals |
| 1 | ○ | Other plants |
| 33 | ○ | Rivers |
| 59 | ● | The soil |
| 2 | ○ | I don't know. |
| 1 | | No response |
| 100% | | |

EXERCISE 126

(9: 2-12)

Most scientists think that the center of the Earth is very

| Age 9 | | |
|---|---|---|
| 23% | ○ | cold. |
| 9 | ○ | dusty. |
| 58 | ● | hot. |
| 6 | ○ | muddy. |
| 5 | ○ | I don't know. |
| 0 | | No response |
| 101% | | |

EXERCISE 127

(9: 2-11)

The Sun and a penny are alike in which of the following ways?

| Age 9 | | |
|---|---|---|
| 5% | ○ | Both weigh the same. |
| 57 | ● | Both are made of atoms. |
| 14 | ○ | Both are made of metals. |
| 9 | ○ | Both are at the same temperature. |
| 14 | ○ | I don't know. |
| 0 | | No response |
| 99% | | |

EXERCISE 128

(9: 6-4)

Our Sun is a

| Age 9 | | |
|---|---|---|
| 15% | ○ | planet. |
| 12 | ○ | satellite. |
| 16 | ○ | solar system. |
| 52 | ● | star. |
| 5 | ○ | I don't know. |
| 1 | | No response |
| 101% | | |

EXERCISE 129

(9: 7-16)

It is sunny, there is little wind, and a thermometer outdoors in the shade looks like the picture below.

How should you dress to be comfortable outdoors?

| Age 9 | | |
|---|---|---|
| 4% | ○ | Wear a rain suit. |
| 11 | ○ | Just wear your indoor clothes. |
| 54 | ● | Put on a sweater or light coat over your indoor clothes. |
| 25 | ○ | Put on a heavy coat, muffler, wool cap, and boots over your indoor clothes. |
| 1 | ○ | I don't know. |
| 0 | | No response |
| 94% | | |

EXERCISE 130

(9: 5-4) (similar to Exercise 205)

The temperature that is thought most comfortable for a schoolroom is about

| Age 9 | | |
|---|---|---|
| 15 % | o | 40° Fahrenheit. |
| 18 | o | 50° Fahrenheit. |
| 52 | • | 70° Fahrenheit. |
| 5 | o | 90° Fahrenheit. |
| 3 | o | 100° Fahrenheit. |
| 8 | o | I don't know. |
| 0 | | No response |
| 101 % | | |

EXERCISE 131

(9: 1-4)

Cactus plants can live in the desert because

| Age 9 | | |
|---|---|---|
| 12 % | o | they are all very large. |
| 4 | o | they have large flowers. |
| 49 | • | they lose little water through leaves. |
| 24 | o | there are no animals in the desert to eat them. |
| 11 | o | I don't know. |
| 1 | | No response |
| 101 % | | |

EXERCISE 132

(9: 1-9)

A different substance is formed when

| Age 9 | | |
|---|---|---|
| 12 % | o | cloth is cut. |
| 12 | | a cup breaks. |
| 46 | • | a candle burns. |
| 13 | o | a piece of chalk falls apart. |
| 16 | o | I don't know. |
| 0 | | No response |
| 99 % | | |

EXERCISE 133

(9: 2-15)

Tom wanted to find out whether plants can grow better in the dark or in the light. He put a pot with 6 radish seeds in a dark room and a pot with 6 bean seeds on the window sill.

He added the same amount of water to both pots. The bean seeds grew better than the radish seeds, so Tom said his plants grow best in the light.

To be able to say this, he should have

| Age 9 | | |
|---|---|---|
| 14 % | o | watered both pots more. |
| 15 | o | watered the radish seeds more. |
| 44 | • | put the same kind of seeds in both pots. |
| 12 | o | grown the seeds in water instead of soil. |
| 15 | o | don't know. |
| 0 | | No response |
| 100 % | | |

EXERCISE 134

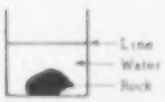
(9: 2-4)

Which of the following insects spread serious human diseases?

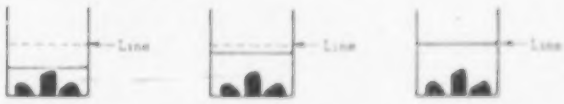
| Age 9 | | |
|---|---|---|
| 6 % | o | Ants |
| 19 | o | Honeybees |
| 44 | • | Houseflies |
| 22 | o | Moths |
| 9 | o | I don't know. |
| 0 | | No response |
| 100 % | | |

EXERCISE 135

(9: 2-9)




When a rock is put into a pail of water, the water comes up to the line as the picture above shows. If the rock is broken into three pieces, which of the following pictures shows how high the water is?




| Age 9 | | |
|---|---|---|
| 12 % | o | A |
| 10 | o | B |
| 36 | • | C |
| 17 | o | D |
| 14 | o | E |
| 9 | o | I don't know. |
| 1 | | No response |
| 99 % | | |

EXERCISE 136

(9: 2-18)

Which of the following is true of all matter?

| Age 9 | | |
|---|---|---|
| 12 % | o | It has a shine. |
| 19 | o | It has no taste. |
| 36 | • | It takes up space. |
| 10 | o | It has a square shape. |
| 23 | o | I don't know. |
| 0 | | No response |
| 100 % | | |

EXERCISE 137

(N: 1458)

A quart of which of the following would weigh the least?

Age 5

| | | |
|---|---|---|
| 7% | o | Air |
| 37 | • | Mercury |
| 1 | o | Gasoline |
| 45 | o | Water |
| 7 | o | I don't know. |
| 3 | | No response |
| 100% | | |

EXERCISE 138

(N: 1437)

Some after a cold front has passed over St. Louis, one expects to find it in St. Louis

Age 5

| | | |
|---|---|---|
| 14% | • | Clearing skies. |
| 9 | o | [illegible] |
| 14 | o | Low atmospheric pressure. |
| 43 | o | The start of a 3 - day snow. |
| 19 | o | I don't know. |
| 3 | | No response |
| 99% | | |

EXERCISE 139

(N: 1411)

Could a rock be broken into smaller and smaller pieces forever and still be rock?

Age 5

| | | |
|---|---|---|
| 21% | o | Yes, because most rocks are made up of several things. |
| 35 | o | Yes, because there is no smallest piece of rock. |
| 27 | • | No, because you would finally get to atoms. |
| 27 | o | No, because rocks are very hard. |
| 6 | o | I don't know. |
| 3 | | No response |
| 102% | | |

EXERCISE 140

(N: 1401)

Coal is formed from

Age 5

| | | |
|---|---|---|
| 11% | • | Dead plants. |
| 14 | o | Sand and mud. |
| 1 | o | Tiny sea animals. |
| 54 | o | Lava from volcanoes. |
| 19 | o | I don't know. |
| 3 | | No response |
| 100% | | |

EXERCISE 141

(N: 1401)

A pint of water at a temperature of 51° Fahrenheit is mixed with a pint of water at 71° Fahrenheit. The temperature of the water just after mixing will be About

Age 5

| | | |
|---|---|---|
| 6% | o | 21° F. |
| 2 | o | 51° F. |
| 7 | • | 61° F. |
| 5 | o | 71° F. |
| 69 | o | 121° F. |
| 12 | o | I don't know. |
| 3 | | No response |
| 99% | | |

EXERCISE 14C

(No. 13-23)

We want you to use this balance. The pivot point is the rail. The balance beam is the piece of metal which can turn on the pivot point. The balance beam is level when nothing is hanging from its hooks. The number by each hook on the beam tells the number of inches that hook is from the pivot point.

A. Hang one weight 4 inches left of the pivot point. The beam is not level now. Hang a second weight so that the beam is level again. Try to balance the beam on your first try, but keep trying until the beam is level. Where did you hang the second weight? 2R

Age 7

| | | |
|---|---|---|
| 44 | ● | Acceptable |
| 1 | | Unacceptable |
| 2 | | No response |
| 100 | | |

EXERCISE 14D

(No. 13-24)

We want you to use this balance. The pivot point is the rail. The balance beam is the piece of metal which can turn on the pivot point. The balance beam is level when nothing is hanging from its hooks. The number by each hook on the beam tells the number of inches that hook is from the pivot point.

A. Hang two weights 4 inches left of the pivot point. The beam is not level now. Hang a third weight so that the beam is level again. Try to balance the beam on your first try, but keep trying until the beam is level. Where did you hang the third weight? 2R

Age 7

| | | |
|---|---|---|
| 44 | ● | Acceptable |
| 1 | | Unacceptable |
| 2 | | No response |
| 100 | | |

EXERCISE 14E

(No. 3-2)

Six leaves usually grow off more nodes than little leaves. Which of the following leaves grows off the most nodes?

Age 9

| | | |
|---|---|---|
| 23 | ● | |
| 2 | | |
| 4 | | |
| 7 | | |
| 3 | | I don't know. |
| 0 | | No response |
| 100 | | |

EXERCISE 14F

(No. 3-3)

Bobby has a flat tire on his bicycle. He pumps the tire up with an air pump and returns to ride. In a few minutes the tire is flat again. To fix the tire, Bobby must find

Age 9

| | | |
|---|---|---|
| 10 | | a better air pump. |
| 3 | | whether the tire is made of rubber. |
| 73 | ● | where the air leaks out of the tire. |
| 2 | | how many minutes it takes the tire to go flat. |
| 8 | | I don't know. |
| 3 | | No response |
| 100 | | |

EXERCISE 14G

(No. 7-17B) (similar to Exercise 27F)

| Weights of some Chemical Elements Found in a 150 pound Human: | |
|---|---|
| Calcium | 3 pounds |
| Carbon | 29 pounds |
| Hydrogen | 15 pounds |
| Oxygen | 94 pounds |
| Phosphorus | 14 ounces |
| Sulfur | 2 ounces |
| Salts | 4 ounces |

1. From the chart above, which chemical element is found in the GREATEST amount in the body?

Age 9

| | | |
|---|---|---|
| 24 | | Calcium |
| 2 | | Carbon |
| 6 | | Hydrogen |
| 61 | ● | Oxygen |
| 6 | | Phosphorus |
| 1 | | |
| 7 | | I don't know. |
| 2 | | No response |
| 100 | | |

EXERCISE 147

(9: 6-6)

Some said that if you mix salt and sugar with water and let the mixture stand you get salt-water taffy--a kind of candy. Which of the following would be the best way for you to test this idea?

Age 9

| | | |
|---|---|---|
| 3 % | O | Take a vote among your friends. |
| 11 | O | Buy some salt-water taffy and see if it has salt in it. |
| 7 | O | Find out if salt and sugar have the same chemicals in them. |
| 6 | O | Grind up some salt-water taffy to see if you get salt, sugar, and water. |
| 66 | ● | Try to mix salt, sugar, and water, let them stand, and see what happens. |
| 5 | O | I don't know. |
| 0 | | No response |
| 100 % | | |

EXERCISE 148

(9: 7-13)

A doctor kept records of breathing rates of people when they were resting. He made the chart below.

BREATHING RATES

| Person | Breaths in a minute |
|---|---|
| Baby boys | 38 |
| 7 -yr. -old girls | 25 |
| 7 -yr. -old boys | 25 |
| 10 -yr. -old boys | 20 |
| Mothers | 16 |

The chart suggests that

Age 9

| | | |
|---|---|---|
| 12 % | O | boys breathe faster than girls. |
| 2 | O | girls breathe faster than boys. |
| 14 | O | older people breathe faster than younger people. |
| 56 | ● | younger people breathe faster than older people. |
| 6 | O | I don't know. |
| 0 | | No response |
| 100 % | | |

EXERCISE 149

(9: 6-6)

John took the outside temperature in the morning, at noon, and at night for two days. His record is shown below.

| Day | Morning | Noon | Night |
|---|---|---|---|
| Tuesday | 19°F | 16°F | 14°F |
| Wednesday | 20°F | 16°F | 11°F |

When was the temperature highest?

Age 9

| | | |
|---|---|---|
| 11 % | O | Tuesday morning |
| 7 | O | Tuesday noon |
| 63 | ● | Wednesday morning |
| 10 | O | Wednesday noon |
| 5 | O | I don't know. |
| 2 | | No response |
| 100 % | | |

EXERCISE 150

(9: 7-17A) (similar to Exercise 231)

| Weights of some Chemical Elements Found in a 100 pound Human | |
|---|---|
| Calcium | 2 pounds |
| Carbon | 18 pounds |
| Hydrogen | 10 pounds |
| Oxygen | 64 pounds |
| Phosphorus | 14 ounces |
| Sodium | 2 ounces |
| Sulfur | 4 ounces |

A. From the chart above, which of the following chemical elements is found in the SMALLEST amount in the body?

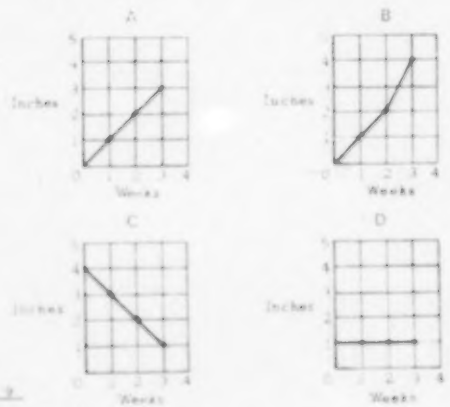
Age 9

| | | |
|---|---|---|
| 14 % | O | Calcium |
| 5 | O | Carbon |
| 8 | O | Hydrogen |
| 54 | ● | Sodium |
| 7 | O | Sulfur |
| 11 | O | I don't know. |
| 1 | | No response |
| 100 % | | |

EXERCISE 151

(9: 8-4)

A plant grows this way: The first week it is 1 inch high. The second week it is 2 inches high. The third week it is 4 inches high. Which of the following graphs shows this growth?




Age 9

| | | |
|---|---|---|
| 11 % | O | A |
| 51 | ● | B |
| 13 | O | C |
| 4 | O | D |
| 11 | O | I don't know. |
| 0 | | No response |
| 99 % | | |

EXERCISE 152

(9: 2-10) (overlaps Exercise 435)

Why do very few people get smallpox in the United States today?

Age 9

| | | |
|---|---|---|
| 12 % | O | The weather conditions have changed. |
| 50 | ● | Most people get smallpox vaccinations. |
| 6 | O | People move more often than they used to. |
| 4 | O | People drink more milk today than ever before. |
| 17 | O | All the germs that cause smallpox have been killed. |
| 11 | O | I don't know. |
| 0 | | No response |
| 100 % | | |

EXERCISE 153

(9: 4-15)

You turn on a water faucet in your home and find that no water comes out. Which of the following could NOT have caused this to happen?

| Age 9 | | |
|---|---|---|
| 35% | ● | The sink is full of water. |
| 9 | O | The water pipe if full of rust. |
| 26 | O | A water pipe is broken somewhere. |
| 26 | O | Your home has been cut off from the water supply. |
| 3 | O | I don't know. |
| 0 | | No response |
| 99% | | |

EXERCISE 154

(9: 1-5)

Ice melts to water at 32°F. If water is cooled from 40°F, one should expect the freezing to take place at

| Age 9 | | |
|---|---|---|
| 31 % | O | 30°F or lower. |
| 17 | ● | 32°F. |
| 7 | O | 33°F. |
| 30 | O | 34°F or higher. |
| 14 | O | I don't know. |
| 0 | | No response |
| 99 % | | |

# OBJECTIVE III: Understand the Investigative Nature of Science

EXERCISE 155

(9: 1-19)

A man has been planting seeds and keeping records of how fast they grow. Could he be doing a science experiment?

| Age 9 | | |
|---|---|---|
| 91% | ● | Yes |
| 7 | O | No |
| 2 | O | I don't know. |
| 0 | | No response |
| 100 % | | |

EXERCISE 156

(9: 3-8)

Mary blew up a balloon and rubbed it against the wall of her room. When she took her hand away, the balloon stayed on the wall without falling. Mary's friends who saw this said the following things about the balloon. Which is the most scientific?

| Age 9 | | |
|---|---|---|
| 7 % | O | I do not believe that the balloon stayed up. |
| 9 | O | It is a magic trick and cannot be explained. |
| 3 | O | The balloon wanted to stay on the wall and not fall down. |
| 78 | ● | I cannot explain it, but there must be a reason why it stays up. |
| 3 | O | I don't know. |
| 0 | | No response |
| 100% | | |

EXERCISE 157

(9: 6-3) (similar to Exercise 242)

Scientists would have most trouble testing which of the following?

| Age 9 | | |
|---|---|---|
| 12 % | O | I have a fever. |
| 6 | O | I weigh 101 pounds. |
| 14 | O | I am 62 inches tall. |
| 13 | O | I can lift a 20-pound box. |
| 38 | ● | My dog is better than your dog. |
| 16 | O | I don't know. |
| 1 | | No response |
| 100 % | | |

EXERCISE 158

(9: 8-14) (overlaps Exercise 244)

What is a scientific theory?

| Age 9 | | |
|---|---|---|
| 4 % | O | It uses arithmetic. |
| 13 | O | It describes a scientist. |
| 27 | O | It describes an experiment. |
| 10 | O | It tells all there is to know about something. |
| 22 | ● | It explains why some things act the way they do. |
| 10 | O | I don't know. |
| 0 | | No response |
| 101 % | | |

EXERCISE 159

(9: 5-12)

In science one is LEAST likely to do which of the following things with an apple?

| Age 9 | | |
|---|---|---|
| 17% | O | Weigh it. |
| 11 | O | Measure its size. |
| 11 | O | Describe its color. |
| 22 | ● | Write a poem about it. |
| 31 | O | Find how many seeds it has. |
| 9 | O | I don't know. |
| 0 | | No response |
| 101% | | |

## Have Attitudes about and Appreciation of Scientists, Science, and the Consequences of Science That Stem from Adequate Understandings

EXERCISE 160

(9: 8-10)

Do you think that the number thirteen (13) brings you bad luck?

| Age 9 | | |
|---|---|---|
| 20 % | ○ | Yes |
| 74 | ● | No |
| 6 | ○ | I don't know. |
| 0 | | No response |
| 100 % | | |

EXERCISE 161

(9: 5-8)

Which of the following will cause you to have bad luck for several years?

| Age 9 | | |
|---|---|---|
| 28 % | ○ | Breaking a mirror |
| 10 | ○ | Walking under a ladder |
| 12 | ○ | Letting a black cat cross your path |
| 45 | ● | None of these |
| 4 | ○ | I don't know. |
| 1 | | No response |
| 100 % | | |

# RELEASED EXERCISES—Age 13

## OBJECTIVE I: Know the Fundamental Facts and Principles of Science

EXERCISE 201

(13: 7-15) (overlaps Exercise 101)

Where does a human baby come from?

| Age 13 | | |
|---|---|---|
| 0 % | ○ | The stork brings the baby. |
| 98 | ● | The baby comes from its mother's body. |
| 0 | ○ | The doctor gives the baby to the mother. |
| 0 | ○ | The father buys the baby for the mother. |
| 0 | ○ | The hospital keeps many babies and the mother picks one out. |
| 0 | ○ | I don't know. |
| 1 | | No response |
| 99 % | | |

Not administered to the in-school sample in one Southeastern county and one Southeastern city at the request of state or local authorities.

EXERCISE 202

(13: 1-1) (overlaps Exercise 103)

For which of the following reasons should you brush your teeth?

| Age 13 | | |
|---|---|---|
| 0 % | ○ | To straighten your teeth |
| 1 | ○ | To make your teeth harder |
| 0 | ○ | To make your teeth sharper |
| 0 | ○ | To help your teeth grow larger |
| 98 | ● | To help keep your teeth from decaying |
| 0 | ○ | I don't know. |
| 0 | | No response |
| 99 % | | |

EXERCISES 203

(13: 4-10) (similar to Exercise 106)

On a summer day, which of the following clouds is most likely to bring rain?

| Age 13 | | |
|---|---|---|
| 1 % | ○ | Thin fluffy clouds |
| 1 | ○ | Red clouds at sunset |
| 91 | ● | Thick dark-gray clouds |
| 1 | ○ | Clouds that look like white sheep |
| 1 | ○ | A few lines of clouds high in the sky |
| 1 | ○ | I don't know. |
| 0 | | No response |
| 100 % | | |

EXERCISE 204

(13: 7-11) (overlaps Exercise 302)

Which of the following would most closely represent a balanced meal?

Age 13

89 % ● Steak, bread, carrots, and milk

1 ○ Ice cream soda and cake

5 ○ Potatoes, oatmeal, bread, and bananas

3 ○ Poultry, steak, and fish

1 ○ Hamburger and cake

1 ○ I don't know.

0 No response

99 %

EXERCISE 205

(13: 8-2) (similar to Exercise 130)

The temperature that is considered most comfortable for a schoolroom is about

Age 13

| | | |
|---|---|---|
| 1 % | 0 | 40° Fahrenheit. |
| 7 | 0 | 50° Fahrenheit. |
| 86 | ● | 70° Fahrenheit. |
| 2 | 0 | 90° Fahrenheit. |
| 0 | 0 | 100° Fahrenheit. |
| 3 | 0 | I don't know. |
| 0 | | No response |
| 99 % | | |

Exercise 206

(13: 6-11)

Fanning can make a campfire burn better because the fanning

Age 13

| | | |
|---|---|---|
| 86 | 0 | raises the atmospheric pressure. |
| 2 | 0 | warms materials to their kindling points. |
| 1 | 0 | increases the supply of material that can burn. |
| 79 | ● | increases the supply of oxygen for the burning. |
| 11 | 0 | provides the energy needed to keep the fire going. |
| 2 | 0 | I don't know. |
| 0 | | No response |
| 99 % | | |

EXERCISE 207

(13: 4-1)

Which of the following diseases presently CANNOT be controlled by a vaccine that one receives by inoculation (shot) or swallowing?

Age 13

| | | |
|---|---|---|
| 78 % | ● | Cancer |
| 7 | 0 | Polio |
| 2 | 0 | Smallpox |
| 3 | 0 | Tetanus |
| 4 | 0 | Typhoid fever |
| 5 | 0 | I don't know. |
| 1 | | No response |
| 100 % | | |

EXERCISE 208

(13: 5-8)

Which of the following could be done on the Moon, where there is no air?

Age 13

| | | |
|---|---|---|
| 1 % | 0 | Flying a kite |
| 3 | 0 | Building a bonfire |
| 2 | 0 | Flying an airplane |
| 17 | 0 | Floating a balloon |
| 74 | ● | Launching a rocket |
| 3 | 0 | I don't know. |
| 0 | | No response |
| 100 % | | |

EXERCISE 209

(13: 4-6)

Which of the following is usually true of sedimentary rock?

Age 13

| | | |
|---|---|---|
| 65 % | ● | It is formed in layers. |
| 5 | 0 | It has large shiny crystals. |
| 5 | 0 | It will dissolve easily in water. |
| 4 | 0 | It is formed on mountain tops. |
| 3 | 0 | It can be melted over a burner flame. |
| 18 | 0 | I don't know. |
| 0 | | No response |
| 100 % | | |

EXERCISE 210

(13: 5-4)

Recent scientific observations indicate that the earliest men on Earth

Age 13

| | | |
|---|---|---|
| 1 % | 0 | lived in cities. |
| 4 | 0 | lived on ocean beaches. |
| 63 | ● | were small, hairy, and stooped. |
| 4 | 0 | had brains the size of a walnut. |
| 12 | 0 | lived near the north and south poles. |
| 12 | 0 | I don't know. |
| 0 | | No response |
| 100 % | | |

EXERCISE 211

(13: 3-13) (overlaps Exercise 414)

Which of the following is true of hot water as compared with cold water?

Age 13

| | | |
|---|---|---|
| 9 % | 0 | It is denser. |
| 3 | 0 | It is easier to see through. |
| 61 | ● | Its molecules are moving faster. |
| 9 | 0 | It has more free oxygen dissolved in it. |
| 6 | 0 | It has more free nitrogen dissolved in it. |
| 12 | 0 | I don't know. |
| 0 | | No response |
| 100 % | | |

EXERCISE 212

(13: 5-12) (overlaps Exercise 305) (similar to Exercise 403)

Information about which one of the following is most important in predicting weather?

Age 13

| | | |
|---|---|---|
| 1 % | 0 | The available supplies of water |
| 11 | 0 | The daily extremes of humidity |
| 4 | 0 | The daily extremes of wind speed |
| 17 | 0 | The daily extremes of temperature |
| 59 | ● | The movement and characteristics of air masses |
| 6 | 0 | I don't know. |
| 0 | | No response |
| 98 % | | |

EXERCISE 213

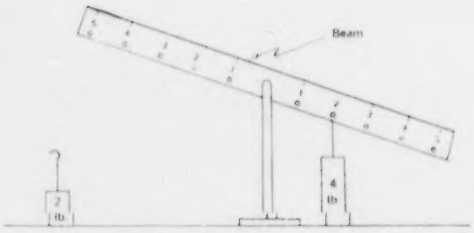
(13: 8-7)

Which of the following would LEAST upset the balance of animal and plant life in a small area?

| Age 13 | | |
|---|---|---|
| 24 % | o | Burning a forest |
| 5 | o | Draining a swamp |
| 6 | o | Constructing a dam |
| 57 | ● | Broadcasting radio waves |
| 5 | o | Killing all hawks, owls, and vultures in the area |
| 3 | o | I don't know. |
| 0 | | No response |
| 100 % | | |

EXERCISE 214

(13: 7-4)




In order to make the beam balance, you should hang a 2-pound weight on the left-hand side at position

| Age 13 | | |
|---|---|---|
| 6 % | o | 1. |
| 14 | o | 2. |
| 6 | o | 3. |
| 55 | ● | 4. |
| 14 | o | 5. |
| 4 | o | I don't know. |
| 0 | | No response |
| 99 % | | |

EXERCISE 215

(13: 1-2) (overlaps Exercise 411)

Flower seeds develop from

| Age 13 | | |
|---|---|---|
| 2 % | o | leaves. |
| 54 | ● | ovules. |
| 15 | o | petals. |
| 15 | o | roots. |
| 6 | o | stems. |
| 9 | o | I don't know. |
| 0 | | No response |
| 101 % | | |

EXERCISE 216

(13: 4-2)

A spoon in a glass of water appears to bend sharply at the water surface. This apparent bending is due to

| Age 13 | | |
|---|---|---|
| 7 % | o | absorption. |
| 5 | o | color bands. |
| 7 | o | interference. |
| 51 | ● | refraction. |
| 10 | o | shadows. |
| 15 | o | I don't know. |
| 0 | | No response |
| 100 % | | |

EXERCISE 217

(13: 6-10) (similar to Exercise 413)

Most of the chemical energy of the gasoline burned in a car is not used to move the car but is changed into

| Age 13 | | |
|---|---|---|
| 24 % | o | electricity. |
| 48 | ● | heat. |
| 1 | o | light. |
| 8 | o | magnetism. |
| 3 | o | sound. |
| 16 | o | I don't know. |
| 0 | | No response |
| 100 % | | |

EXERCISE 218

(13: 7-2) (similar to Exercise 317)

Mercury can be enclosed in glass to make a thermometer because mercury

| Age 13 | | |
|---|---|---|
| 11 % | o | is a metal |
| 8 | o | is more dense than glass. |
| 19 | o | conducts heat better than glass. |
| 2 | o | conducts electricity better than glass. |
| 45 | ● | expands more than glass when both are heated together. |
| 14 | o | I don't know. |
| 0 | | No response |
| 99 % | | |

EXERCISE 219

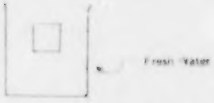
(13: 3-5)

Which of the following best describes the results of pasteurization of milk?

| Age 13 | | |
|---|---|---|
| 25 % | o | All bacteria are killed. |
| 23 | o | The milk is homogenized. |
| 4 | o | The taste of milk is improved. |
| 40 | ● | Bacteria harmful to man are killed. |
| 5 | o | The milk is permanently kept from spoiling. |
| 3 | o | I don't know. |
| 0 | | No response |
| 100 % | | |

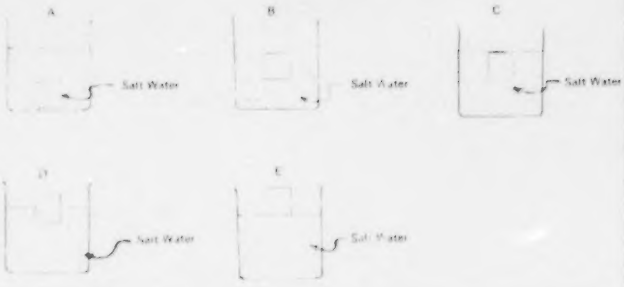
## EXERCISE 220

(13: 4-9)




A block of wood floats in fresh water as shown above. If this block were placed in salt water from the ocean, which of the following diagrams shows what would happen?

| Age 13 | | |
|---|---|---|
| 13 % | O | A |
| 4 | O | B |
| 8 | O | C |
| 19 | ● | D |
| 28 | O | E |
| 8 | O | I don't know. |
| 0 | | No response |
| 100 % | | |




## EXERCISE 221

(13: 7-14) (overlaps Exercise 422)

Most caves are formed by the action of underground water on

| Age 13 | | |
|---|---|---|
| 10 % | O | granite. |
| 38 | ● | limestone. |
| 4 | O | pumice. |
| 23 | O | sandstone. |
| 6 | O | shale. |
| 18 | O | I don't know. |
| 0 | | No response |
| 99 % | | |

## EXERCISE 222

(13: 8-8) (similar to Exercise 114)

In terms of the theory of natural selection, what is the explanation of why giraffes have come to have such long necks?

| Age 13 | | |
|---|---|---|
| 8 % | O | Stretching to get food in high trees has made their necks longer. |
| 3 | O | There is something inside of giraffes which keeps making longer necks. |
| 12 | O | Giraffe food contained vitamins which caused vertebrae to lengthen. |
| 20 | O | Giraffe necks have gotten longer and longer as time has gone on, but nobody has any idea why this is. |
| 38 | ● | Giraffes born with the longest necks have been able to stay alive when food was scarce and have passed this trait on to their offspring. |
| 12 | O | I don't know. |
| 0 | | No response |
| 100 % | | |

## EXERCISE 223

(13: 7-13) (overlaps Exercise 321)

Which of these is characteristic of birds but of no other animals?

| Age 13 | | |
|---|---|---|
| 17 % | O | Ability to fly |
| 2 | O | Ability to lay eggs |
| 10 | O | Tendency to migrate |
| 56 | ● | Body covering of feathers |
| 10 | O | Regulated body temperature |
| 4 | O | I don't know. |
| 1 | | No response |
| 100 % | | |

## EXERCISE 224

(13: 7-12)

Why do we think that matter is made up of atoms?

| Age 13 | | |
|---|---|---|
| 41 % | O | We can see atoms with a microscope. |
| 1 | O | We can see atoms with our unaided eyes. |
| 2 | O | We can see atoms with a magnifying glass. |
| 34 | ● | Matter behaves as if it were made up of atoms. |
| 11 | O | A famous Greek man said many hundreds of years ago that matter is made of atoms. |
| 11 | O | I don't know. |
| 0 | | No response |
| 99 % | | |

## EXERCISE 225

(13: 9-6)

Which of the following should you do when a person faints?

| Age 13 | | |
|---|---|---|
| 0 % | O | Tightly bandage him. |
| 32 | ● | Lay him down and keep him warm. |
| 1 | O | Hold him up and apply hot packs. |
| 12 | O | Hold him up and apply cold packs. |
| 47 | O | Lay him down and apply cold packs. |
| 7 | O | I don't know. |
| 0 | | No response |
| 100 % | | |

EXERCISE 226

(13: 9-10)

Which of the following most clearly forms molecules different from those present at the start?

| Age 13 | | |
|---|---|---|
| 41 % | 0 | Ice melting |
| 4 | 0 | A cup breaking |
| 4 | 0 | Cloth being torn |
| 27 | ● | A candle burning |
| 11 | 0 | A piece of chalk falling apart |
| 13 | 0 | I don't know. |
| 0 | | No response |
| 100 % | | |

EXERCISE 227

(13: 7-6) (overlaps Exercise 427)

In mammals, which of the following is the center of memory and intelligence?

| Age 13 | | |
|---|---|---|
| 21 % | 0 | Cerebellum |
| 26 | ● | Cerebrum |
| 11 | 0 | Medulla |
| 10 | 0 | Optic nerve |
| 7 | 0 | Spinal cord |
| 25 | 0 | I don't know. |
| 0 | | No response |
| 100 % | | |

EXERCISE 228

(13: 9-7) (overlaps Exercise 425)

A fossil of an ocean fish was found in a rock outcrop on a mountain. This probably means that

| Age 13 | | |
|---|---|---|
| 1 % | 0 | fish once lived on the mountain. |
| 3 | 0 | the relative humidity was once very high. |
| 26 | ● | the mountain was raised up after the fish died. |
| 10 | 0 | fish used to be amphibians like toads and frogs. |
| 53 | 0 | the fossil fish was probably carried to the mountain by a great flood. |
| 5 | 0 | I don't know. |
| 0 | | No response |
| 100 % | | |

## OBJECTIVE II: Possess the Abilities and Skills Needed to Engage in the Processes of Science

EXERCISE 229

(13: 9-13B) (similar to Exercise 145)

| Weights of some Chemical Elements Found in a 100 pound Human | |
|---|---|
| Calcium | 2 lb. |
| Carbon | 18 lb. |
| Hydrogen | 10 lb. |
| Oxygen | 64 lb. |
| Phosphorus | 14 oz. |
| Sodium | 2 oz. |
| Sulfur | 4 oz. |

B. From the chart above, which chemical element is found in the GREATEST amount in the body?

| Age 13 | | |
|---|---|---|
| 2 % | 0 | Calcium |
| 1 | 0 | Carbon |
| 1 | 0 | Hydrogen |
| 92 | ● | Oxygen |
| 1 | 0 | Phosphorus |
| 1 | 0 | I don't know. |
| 0 | | No response |
| 98 % | | |

EXERCISE 230

(13: 4-15) (overlaps Exercise 436)

A man notices that the paint on one side of his house is not lasting as well as the paint on the other sides. Which of the following is the most likely cause?

| Age 13 | | |
|---|---|---|
| 5 % | 0 | Termites |
| 8 | 0 | Cosmic rays |
| 83 | ● | Wind or sun |
| 0 | 0 | Fallout from atom bombs |
| 1 | 0 | Sonic booms from low-flying jets |
| 3 | 0 | I don't know. |
| 0 | | No response |
| 100 % | | |

## EXERCISE 231

(13: 9-13A) (similar to Exercise 150)

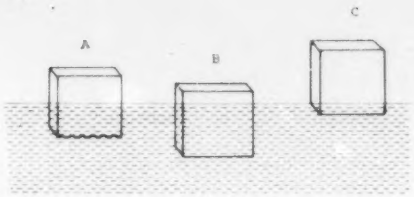
| Weights of some Chemical Elements Found in a 100 pound Human | |
|---|---|
| Calcium | 2 lb. |
| Carbon | 18 lb. |
| Hydrogen | 10 lb. |
| Oxygen | 64 lb. |
| Phosphorus | 14 oz. |
| Sodium | 2 oz. |
| Sulfur | 4 oz. |

A. From the chart above, which of the following chemical elements is found in the least amount in the body?

| Age 13 | | |
|---|---|---|
| 3 % | O | Calcium |
| 3 | O | Carbon |
| 4 | O | Hydrogen |
| 81 | ● | Sodium |
| 6 | O | Sulfur |
| 2 | O | I don't know. |
| 1 | | No response |
| 100 % | | |

## EXERCISE 232

(13: 5-13)

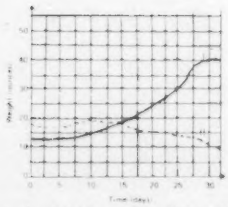



The three solid objects shown above have the same volume. If they float as shown in the diagram, which one weighs the most?

| Age 13 | | |
|---|---|---|
| 0 % | O | Object A |
| 75 | ● | Object B |
| 4 | O | Object C |
| 6 | O | They all weigh the same. |
| 14 | O | It is impossible to tell without additional information. |
| 1 | O | I don't know. |
| 0 | | No response |
| 100 % | | |

## EXERCISE 233

(13: 3-14)

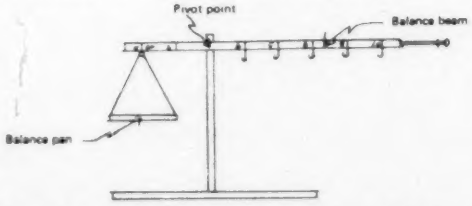


Two guinea pigs, I and II, were put on different diets for a month. The graph above shows what happened to their weights. Which of the following statements is correct according to the information in the graph?

| Age 13 | | |
|---|---|---|
| 8 % | O | Guinea pig I lost weight while guinea pig II gained weight. |
| 3 | O | Guinea pig I and guinea pig II weighed the same at the beginning of the experiment. |
| 71 | ● | Guinea pig I and guinea pig II weighed the same on the 15th day of the experiment. |
| 4 | O | Guinea pig I was given meat and corn whereas guinea pig II was given sugar and crackers. |
| 9 | O | Guinea pig II lost weight at first, but started to gain about halfway through the experiment. |
| 4 | O | I don't know. |
| 2 | | No response |
| 101 % | | |

## EXERCISE 234

(13: 13-21a1) (overlaps exercises 341 and 438)




The apparatus before you is the same as that shown in the picture. This balance is balanced when the balance beam is level as shown above. The number by each mark on the beam tells the number of inches that mark is from the pivot point.

1. Place one weight in the balance pan. How many inches from the pivot point is the hook on which you must hang one weight to get balance? (4)

| Age 13 | |
|---|---|
| 64 % | Correct |
| 34 | Incorrect |
| 2 | No response |
| 100% | |

The apparatus also included fishweights, one to place in the balance pan, and another to use to achieve balance. The respondent was given 20 minutes to find the answer to this and other questions involving the use of the apparatus (see Exercise 240).

EXERCISE 235

(13: 7-8) (overlaps exercises 413 and 419)

In each of five experiments, two objects were weighed four times each. Which experiment gives the strongest evidence that object I weighs more than object II?

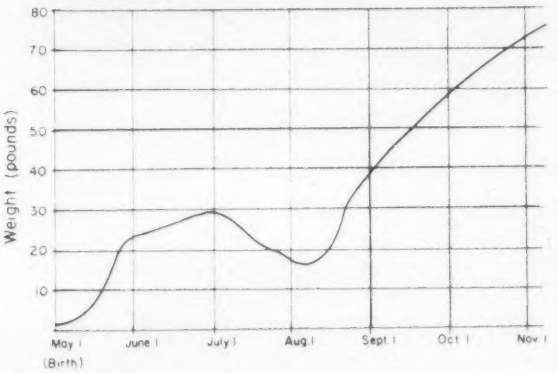
| | | | Object I | Object II |
|---|---|---|---|---|
| 1 Age 13 | | | | |
| 62 % | ● | Experiment A | 80 lb. | 70 lb. |
| | | | 81 lb. | 69 lb. |
| | | | 80 lb. | 71 lb. |
| | | | 82 lb. | 70 lb. |
| 9 | ○ | Experiment B | 69 lb. | 81 lb. |
| | | | 71 lb. | 82 lb. |
| | | | 70 lb. | 80 lb. |
| | | | 70 lb. | 80 lb. |
| 3 | ○ | Experiment C | 70 lb. | 80 lb. |
| | | | 75 lb. | 75 lb. |
| | | | 77 lb. | 73 lb. |
| | | | 80 lb. | 70 lb. |
| 4 | ○ | Experiment D | 80 lb. | 70 lb. |
| | | | 75 lb. | 75 lb. |
| | | | 73 lb. | 77 lb. |
| | | | 70 lb. | 80 lb. |
| 9 | ○ | Experiment E | 80 lb. | 77 lb. |
| | | | 79 lb. | 76 lb. |
| | | | 78 lb. | 75 lb. |
| | | | 77 lb. | 74 lb. |
| 12 | ○ | I don't know | | |
| 2 | | No response | | |
| 100 % | | | | |

EXERCISE 236

(13: 9-14c)

Michael kept a record of his dog's weight from birth on May 1 in order to find out how much dog food to give his dog. The directions on the bag of dog food for feeding a dog are as follows:

| Weight of Dog | Number of Cups of Food Daily |
|---|---|
| Under 20 pounds | 1 |
| 20 to 40 pounds | 2 |
| 41 to 60 pounds | 3 |
| Over 60 pounds | 4 |



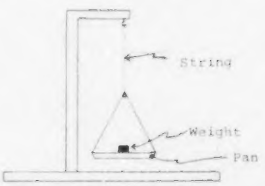

(13: 9-14c)

In what month should the dog's daily allowance have been increased to 4 cups?

| | | |
|---|---|---|
| Age 13 | | |
| 4 % | ○ | July |
| 9 | ○ | August |
| 8 | ○ | September |
| 61 | ● | October |
| 15 | ○ | November |
| 3 | ○ | I don't know. |
| 0 | | No response |
| 100 % | | |

EXERCISE 237

(13: 13-21c1) (overlaps exercises 344 and 441)



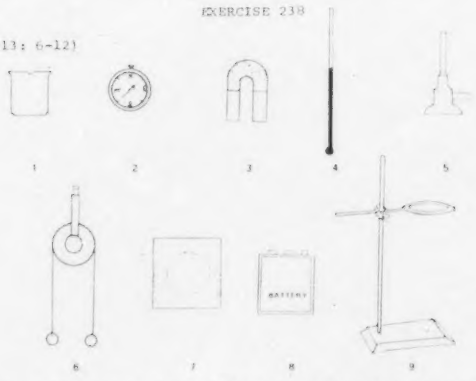

The apparatus before you is a pendulum. You have a watch or clock also.

1. How long does it take for the weight in the pan on the end of the string to swing back and forth ten times?
_____ seconds (An answer between 11 and 15 seconds was scored correct.)

| | | |
|---|---|---|
| Age 13 | | |
| 38 % | | Correct |
| 56 | | Incorrect |
| 6 | | No response |
| 100 % | | |

EXERCISE 238

(13: 6-12)




Select the pieces of apparatus shown above that one would use to find the boiling point of water.

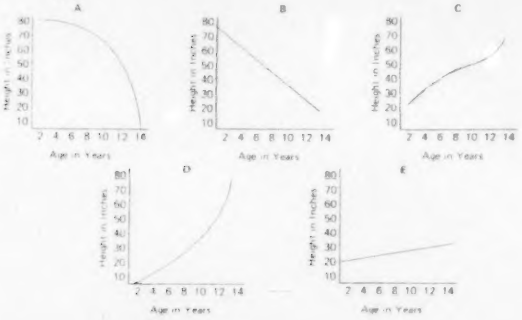
| | | |
|---|---|---|
| Age 13 | | |
| 15 % | ○ | 1, 4, 5, 6, 7 |
| 17 | ○ | 1, 4, 5, 6, 9 |
| 36 | ● | 1, 4, 5, 7, 9 |
| 4 | ○ | 2, 3, 4, 6, 7 |
| 10 | ○ | 4, 5, 6, 8, 9 |
| 17 | ○ | I don't know. |
| 1 | | No response |
| 100 % | | |

EXERCISE 239

(13: 2-9) (similar to Exercise 442)

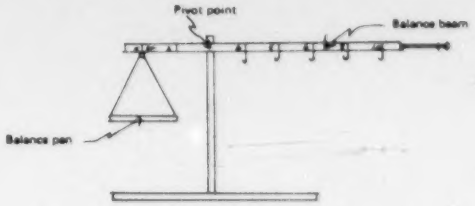
Which of the following graphs could show the average height in inches of a group of children growing at a normal rate plotted against their age in years?

| Age 13 | | |
|---|---|---|
| 16 % | O | A |
| 14 | O | B |
| 27 | ● | C |
| 16 | O | D |
| 10 | O | E |
| 16 | O | I don't know. |
| 0 | | No response |
| 99 % | | |




EXERCISE 240

(13: 13-21a5) (overlaps exercises 349 and 445)




The apparatus before you is the same as that shown in the picture. This balance is balanced when the balance beam is level as shown above. The number by each mark on the beam tells the number of inches that mark is from the pivot point.

(The apparatus also included 10-gram fishweights, a centimeter ruler, and a block of wood 10 x 3 x 2 centimeters. Respondents were given 20 minutes to answer several related questions (e.g., see Exercise 234). The following question was preceded by others which required them to make measurements which would assist them in answering it.)

5. What is the density of the wood block? It is _____ grams per cubic centimeter. (An answer between .38 and .64 was scored correct.)

| Age 13 | |
|---|---|
| 4 % | Correct |
| 70 | Incorrect |
| 25 | No response |
| 99 % | |

## OBJECTIVE III: Understand the Investigative Nature of Science

EXERCISE 241

(13: 7-7) (overlaps Exercise 349)

Skill in which of the following is most useful in scientific research?

| Age 13 | | |
|---|---|---|
| 1 % | O | Music |
| 4 | O | Magic |
| 1 | O | Marketing |
| 79 | ● | Mathematics |
| 12 | O | Manufacturing |
| 3 | O | I don't know. |
| 0 | | No response |
| 100 % | | |

EXERCISE 242

(13: 2-1) (similar to Exercise 157)

Scientists would have most trouble testing which of the following?

| Age 13 | | |
|---|---|---|
| 6 % | O | I have a fever. |
| 4 | O | I am 62 inches tall. |
| 2 | O | I weigh 101 pounds. |
| 8 | O | I can lift a 20-pound box. |
| 73 | ● | My dog is better than your dog. |
| 7 | O | I don't know. |
| 0 | | No response |
| 100 % | | |

EXERCISE 243

(13: 8-14) (overlaps exercises 350 and 446)

Whenever scientists carefully measure any quantity many times, they expect that

| Age 13 | | |
|---|---|---|
| 19 % | O | all of the measurements will be exactly the same. |
| 2 | O | only two of the measurements will be exactly the same. |
| 4 | O | all but one of the measurements will be exactly the same. |
| 69 | ● | most of the measurements will be close but not exactly the same. |
| 6 | O | I don't know. |
| 0 | | No response |
| 100 % | | |

EXERCISE 244

(13: 9-5) (overlaps Exercise 158)

What is a scientific theory?

| Age 13 | | |
|---|---|---|
| 1 % | O | It uses arithmetic. |
| 4 | O | It describes a scientist. |
| 19 | O | It describes an experiment. |
| 14 | O | It tells all there is to know about something. |
| 56 | ● | It explains why some things act the way they do. |
| 5 | O | I don't know. |
| 0 | | No response |
| 99 % | | |

## Objective IV: Have Attitudes about and Appreciation of Scientists, Science, and the Consequences of Science That Stem from Adequate Understandings

EXERCISE [illegible]

(13; 7-12)

Women can be successful scientists.

Age 13

| | | |
|---|---|---|
| 94 % | ● | I believe this statement. |
| 3 | ○ | I don't believe this statement. |
| 1 | ○ | I don't know. |
| 1 | | No response |
| 99 % | | |

EXERCISE [illegible]

(13; 9-12)

Do you think that scientists always work in laboratories?

Age 13

| | | |
|---|---|---|
| 8 % | ○ | Yes. |
| 91 | ● | No. |
| 1 | ○ | I don't know. |
| 1 | | No response. |
| 101 % | | |

EXERCISE [illegible]

(13; 7-16A)

A. Do you ask questions about why things in nature are the way they are?

Age 13

| | | |
|---|---|---|
| 9 % | ● | Often |
| 64 | ○ | Sometimes |
| 27 | ○ | Never |
| 1 | | No response |
| 101 % | | |

## RELEASED EXERCISES—Age 17

## Objective I: Know the Fundamental Facts and Principles of Science

EXERCISE 101

(17; 5-3) (similar to Exercise 401)

Which of the following groups of animals and plants would be found in a desert community?

Age 17

| | | |
|---|---|---|
| 0 % | ○ | Ground hogs, deer, oak, fern |
| 0 | ○ | Grizzly bears, buffaloes, fir, grass |
| 2 | ○ | Yucca, banana, water lilies, cattails |
| 0 | ○ | Starfish, sand dollars, kelp, plankton |
| 98 | ● | Snakes, road runners, cactus, sagebrush |
| 0 | ○ | I don't know. |
| 0 | | No response |
| 99 % | | |

EXERCISE [illegible]

(17; 7-8)

At the present time nearly all gasoline comes from

Age 17

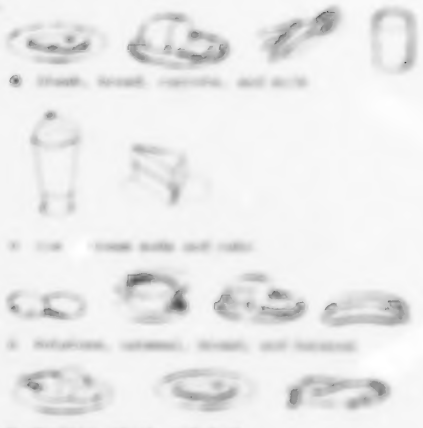
| | | |
|---|---|---|
| 4 % | ○ | coal. |
| 91 | ● | petroleum. |
| 0 | ○ | water. |
| 0 | ○ | wood. |
| 2 | ○ | I don't know. |
| 3 | | No response |
| 99 % | | |

EXERCISE [illegible]

(17; 4-3) (overlaps Exercise 203)

Which of the following would most closely represent a balanced meal?

Age 17



| | | |
|---|---|---|
| 0 | ○ | A. [illegible] |
| 0 | ○ | B. [illegible] |
| 1 | ○ | C. [illegible] |
| 0 | ○ | D. [illegible] |
| 0 | ○ | E. [illegible] |
| 0 | | No response |
| 101 % | | |

EXERCISE 304

(17: 10-10)

Which of the following animals that have been found as fossils in rocks have NEVER been seen alive by man?

| Age 17 | | |
|---|---|---|
| 89 % | ● | Dinosaurs |
| 1 | ○ | Horses |
| 5 | ○ | Locusts |
| 1 | ○ | Oysters |
| 1 | ○ | Shrimp |
| 3 | ○ | I don't know. |
| 0 | | No response |
| 100 % | | |

EXERCISE 305

(17: 8-1) (overlaps Exercise 212) (similar to Exercise 403)

Information about which one of the following is most important in predicting weather?

| Age 17 | | |
|---|---|---|
| 1 % | ○ | The available supplies of water |
| 9 | ○ | The daily extremes of humidity |
| 1 | ○ | The daily extremes of wind speed |
| 9 | ○ | The daily extremes of temperature |
| 77 | ● | The movement and characteristics of air masses |
| 4 | ○ | I don't know. |
| 0 | | No response |
| 101 % | | |

EXERCISE 306

(17: 6-16) (overlaps Exercise 417)

All of the following help to increase the total amount of food available to the human race EXCEPT

| Age 17 | | |
|---|---|---|
| 2 % | ○ | irrigating crops. |
| 12 | ○ | developing hybrids. |
| 2 | ○ | improving fertilizers. |
| 70 | ● | outlawing the use of insecticides. |
| 10 | ○ | controlling the growth of undesirable plants. |
| 4 | ○ | I don't know. |
| 0 | | No response |
| 100 % | | |

EXERCISE 307

(17: 2-3)

Any galaxy contains many

| Age 17 | | |
|---|---|---|
| 2 % | ○ | moons. |
| 22 | ○ | planets. |
| 5 | ○ | satellites. |
| 69 | ● | stars. |
| 1 | ○ | winds. |
| 2 | ○ | I don't know. |
| 0 | | No response |
| 101 % | | |

EXERCISE 308

(17: 5-5) (overlaps Exercise 410)

An electric current in a copper wire involves mainly the movement of

| Age 17 | | |
|---|---|---|
| 5 % | ○ | copper atoms. |
| 10 | ○ | copper molecules. |
| 69 | ● | electrons. |
| 3 | ○ | neutrons. |
| 2 | ○ | protons. |
| 11 | ○ | I don't know. |
| 0 | | No response |
| 100 % | | |

EXERCISE 309

(17: 9-6) (overlaps Exercise 409)

The idea of natural selection is usually associated with the theory of evolution proposed by

| Age 17 | | |
|---|---|---|
| 68 % | ● | Charles Darwin. |
| 1 | ○ | Edward Jenner. |
| 2 | ○ | Jean Lamarck. |
| 7 | ○ | Louis Pasteur. |
| 1 | ○ | Jonas Salk. |
| 19 | ○ | I don't know. |
| 0 | | No response |
| 100 % | | |

EXERCISE 310

(17: 11-1)

Changes such as the conversion of limestone to marble or of soft coal to hard coal are explained as having been brought about

| Age 17 | | |
|---|---|---|
| 12 % | ○ | by sudden cooling of the material. |
| 1 | ○ | by exposure to gases from a volcano. |
| 1 | ○ | by exposure to an underground river. |
| 4 | ○ | by the action of $CO_2$ from the atmosphere. |
| 68 | ● | by heat and pressure below the Earth's surface. |
| 14 | ○ | I don't know. |
| 0 | | No response |
| 100 % | | |

EXERCISE 311

(17: 6-1) (overlaps Exercise 408)

The solid, liquid, and gaseous states of water differ in which of the following ways?

| Age 17 | | |
|---|---|---|
| 1 % | ○ | The number of protons per molecule |
| 4 | ○ | The number of electrons per molecule |
| 4 | ○ | The net charge on the individual molecules |
| 5 | ○ | The number of neutrons per individual molecule |
| 65 | ● | The average speed with which the molecules are moving |
| 20 | ○ | I don't know. |
| 2 | | No response |
| 101 % | | |

Question 121

(17% don't)

Which of the following can be detected with sensitive human eyes?

Age 17

| | | |
|---|---|---|
| 17% | a | Ozone |
| 2 | b | Radio waves |
| 7 | c | Television waves |
| 1 | d | The Earth's magnetic field |
| 43 | e • | Infrared wavelengths of light |
| 7 | f | I don't know. |
| 1 | | No response |
| 81% | | |

Question 122

(17% know)

Scientists refer the surface of matter formed when it is made up of

Age 17

| | | |
|---|---|---|
| 14% | a | Subatomic nuclear particles. |
| 6 | b | Ultimate elementary particles. |
| 53 | c • | Indivisible making particles. |
| 2 | d | Atomic building blocks. |
| 2 | e | Light cubes. |
| 23 | f | I don't know. |
| 1 | | No response |
| 96% | | |

Multiple Use 123

(17% know: Question to Examiner 122)

In terms of the theory of reduced scientism, what is the explanation of why printing have come to have such long names?

Age 17

| | | |
|---|---|---|
| 12% | a | Stretching to get them on high trees has made their necks longer. |
| 1 | b | There is something inside of printers which keeps making longer words. |
| 1 | c | Giraffe food contained vitamins which caused the curtailed to lengthen. |
| 19 | d | Giraffe necks have gotten longer and longer as time has gone on, but nobody has any idea why this is. |
| 58 | e • | Giraffes took with the longest necks have been able to stay alive when food was scarce and have passed this trait on to their offspring. |
| 11 | f | I don't know. |
| 1 | | No response |
| 103% | | |

Question 123

(17% know)

If 2 grams of water at 40°F are mixed with 2 gram of water at 212°F, the temperature of the mixture immediately after mixing will be about

Age 17

| | | |
|---|---|---|
| 23 | a | 40°F. |
| 4 | b | 52°F. |
| 57 | c • | 126°F. |
| 11 | d | 80°F. |
| 2 | e | 212°F. |
| 18 | f | I don't know. |
| 1 | | No response |
| 116% | | |

Question 124

(17% don't) Overlaps Question 126.

Which of the following acts as a stimulant to the heart?

Age 17

| | | |
|---|---|---|
| 74% | a • | Adrenaline |
| 24 | b | Alcohol |
| 2 | c | Aspirin |
| 5 | d | Barbiturates |
| 4 | e | Penicillin |
| 21 | f | I don't know. |
| 2 | | No response |
| 99% | | |

Question 125

(17% don't) Multiple to Question 126)

Warming can be sufficient in order to make a thermometric because warming

Age 17

| | | |
|---|---|---|
| 8% | a | is a metal. |
| 5 | b | is more dense than glass. |
| 11 | c | conducts heat further than glass. |
| 4 | d | has a higher specific heat than glass. |
| 70 | e • | expands more than glass when both are heated together. |
| 13 | f | I don't know. |
| 2 | | No response |
| 113% | | |

Question 126

(17% don't) Overlaps Question 124)

Which of the following acts as a stimulant to the heart?

Age 17

| | | |
|---|---|---|
| 74% | a • | Adrenaline |
| 24 | b | Alcohol |
| 2 | c | Aspirin |
| 5 | d | Barbiturates |
| 4 | e | Penicillin |
| 21 | f | I don't know. |
| 2 | | No response |
| 99% | | |

Question 127

(17% don't)

The most powerful energies, which of the following most nearly describes this energy?

Age 17

| | | |
|---|---|---|
| 8% | a | Atoms are formed from energy. |
| 17 | b | Atoms are transformed into energy. |
| 74 | c • | Atoms are rearranged into new molecules. |
| 1 | d | Molecules are formed from energy. |
| 5 | e | Molecules are connected into energy. |
| 17 | f | I don't know. |
| 2 | | No response |
| 124% | | |

Question 128

(17% don't) Overlaps Question 130)

A ripened fruit is dropped from a cliff 100 feet high. The longer the path taken, the greater is the

Age 17

| | | |
|---|---|---|
| 17% | a | acceleration. |
| 24 | b | gravitational energy. |
| 58 | c • | speed. |
| 6 | d | total energy. |
| 3 | e | volume. |
| 1 | f | I don't know. |
| 2 | | No response |
| 111% | | |

Question 103

(17, 6:22) Interchange Exercises 9:71)

A motor boat can travel 5 miles per hour in a still lake. If this boat travels downstream on a river that is flowing 3 miles per hour, how long will it take the boat to reach a bridge that is 27 miles downstream?

Mark 17.

| | | |
|---|---|---|
| 13.9 | A. | 27 min. |
| 18 | B. | 39 min. |
| 9 | C. | 81 min. |
| 54 | D. | 93 min. |
| 6 | E. | 75 min. |
| 0 | F. | I don't know. |
| 2 | | No response |

170.9

Question 104

(17, 6:47) Interchange Exercises 9:71)

If a person who is a light eater has a tendency to be overweight, it is most likely due to

Mark 17.

| | | |
|---|---|---|
| 2.5 | A. | low basal activities. |
| 2 | B. | a genetically determined trait. |
| 17 | C. | a tendency toward hyperthyroidism. |
| 41 | D. | an unhealthy balance of nitrogen. |
| 44 | E. | highly efficient assimilation of food by the body. |
| 11 | F. | I don't know. |
| 1 | | No response |

220.5

Question 105

(17, 7:07) Interchange Exercises 9:71)

If a person who is a light eater has a tendency to be overweight, it is most likely due to

Mark 17.

| | | |
|---|---|---|
| 2.5 | A. | low basal activities. |
| 2 | B. | a genetically determined trait. |
| 17 | C. | a tendency toward hyperthyroidism. |
| 41 | D. | an unhealthy balance of nitrogen. |
| 44 | E. | highly efficient assimilation of food by the body. |
| 11 | F. | I don't know. |
| 1 | | No response |

220.5

Question 106

(17, 7:22)

The nutrient water within it is absorbed at a faster rate, and since it does actually digest at that same rate, which of the following is correct in comparing the two eaters?

Mark 17.

| | | |
|---|---|---|
| 113.5 | A. | Both have the same tendency for difference metabolisms. |
| 41 | B. | Both have the same tendency for different digestions. |
| 9 | C. | Neither of him a higher tendency and height metabolism. |
| 44 | D. | Jason A has a higher tendency and shorter metabolism. |
| 11 | E. | I don't know. |
| 1 | | No response |

170.5

Question 107

(17, 7:40) Interchange Exercises 9:71)

What is the function of the placenta in a pregnant human female?

Mark 17.

| | | |
|---|---|---|
| 5.5 | A. | To guard the baby out in water |
| 9 | B. | To take the baby waste self matter |
| 41 | C. | To carry nourishment to the baby |
| 11 | D. | To maintain the baby against shocks |
| 5 | E. | To keep the baby's body temperature constant |
| 11 | F. | I don't know. |
| 2 | | No response |

99.5

Question 108

(17, 7:49)

Which of these is characteristic of birds but of no other animals?

Mark 17.

| | | |
|---|---|---|
| 27.5 | A. | Ability to fly |
| 1 | B. | Ability to lay eggs |
| 0 | C. | Teaching by animals |
| 41 | D. | Body covering of feathers |
| 4 | E. | Regulated body temperature |
| 7 | F. | I don't know. |
| 2 | | No response |

227.5

Question 109

(17, 7:57) Interchange Exercises 9:71)

What is the purpose of a fruit on an angiosperm plant?

Mark 17.

| | | |
|---|---|---|
| 114.5 | A. | To spread a flower, or the plant. |
| 58 | B. | To increase the voltage inside the plant. |
| 9 | C. | To decrease the temperature of the plant. |
| 44 | D. | To protect gametes inside of the plant. |
| 2 | E. | To store the temperature of the seeds in the plant. |
| 11 | F. | I don't know. |
| 2 | | No response |

230.5

Question 110

(17, 8:10)

The nutrient water within it is absorbed at a faster rate, and since it does actually digest at that same rate, which of the following is correct in comparing the two eaters?

Mark 17.

| | | |
|---|---|---|
| 113.5 | A. | Both have the same tendency for difference metabolisms. |
| 41 | B. | Both have the same tendency for different digestions. |
| 9 | C. | Neither of him a higher tendency and height metabolism. |
| 44 | D. | Jason A has a higher tendency and shorter metabolism. |
| 11 | E. | I don't know. |
| 1 | | No response |

170.5

Question 111

(17, 8:22) Interchange Exercises 9:71)

What is the function of the placenta in a pregnant human female?

Mark 17.

| | | |
|---|---|---|
| 5.5 | A. | To guard the baby out in water |
| 9 | B. | To take the baby waste self matter |
| 41 | C. | To carry nourishment to the baby |
| 11 | D. | To maintain the baby against shocks |
| 5 | E. | To keep the baby's body temperature constant |
| 11 | F. | I don't know. |
| 2 | | No response |

99.5

Question 112

(17, 8:40)

Jeremy rubbed wool to metal scissors to the metal's

Mark 17.

| | | |
|---|---|---|
| 38.5 | A. | Tendency to a lower temperature. |
| 23 | B. | Stopping body ion movement. |
| 29 | C. | Antagonistic factor. |
| 1 | D. | Attracting metal bits. |
| 1 | E. | Increasing voltage/motion. |
| 11 | F. | I don't know. |
| 1 | | No response |

113.5

Question 113

(17, 8:48)

What nutrient needed in large dose form is native or synthesized inserted in food only?

Mark 17.

| | | |
|---|---|---|
| 9.5 | A. | Mineral nutrients |
| 11 | B. | Nutrients of fat |
| 41 | C. | Metabolic waste |
| 28 | D. | Water waste |
| 7 | E. | I don't know. |
| 2 | | No response |

99.5

EXERCISE 328

(17: 7-42) (similar to Exercise 428)

Two light waves are traveling in a vacuum. The wave with the higher frequency will have the

Age 17

| | | |
|---|---|---|
| 16 % | o | higher speed, |
| 7 | o | lower speed, |
| 23 | o | longer wavelength, |
| 32 | • | shorter wavelength, |
| 9 | o | more nearly horizontal direction. |
| 21 | o | I don't know, |
| 0 | | No response |
| 100 % | | |

EXERCISE 329

(17: 7-43) (similar to Exercise 429)

Which of the following is the amount of DNA present stated correctly:

Age 17

| | | |
|---|---|---|
| 17 % | • | It would be identical in mature egg and sperm cells, |
| 8 | o | It would be identical in sperm cells and liver cells, |
| 9 | o | It would be identical in a mature egg cell and a nerve cell, |
| 3 | o | It would be half as much in a thyroid cell as in a liver cell, |
| 11 | o | It would be half as much in the fertilized egg as in a thyroid gland cell, |
| 51 | o | I don't know, |
| 0 | | No response |
| 100 % | | |

EXERCISE 330

(17: 9-48) (similar Exercise 430)

In the ovaries, in human females, the egg is released how many days after menstruation begins?

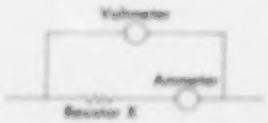
Age 17

| | | |
|---|---|---|
| 25 % | o | 2 days |
| 11 | o | 9 days |
| 29 | • | 14 days |
| 4 | o | 23 days |
| 11 | o | 28 days |
| 20 | o | I don't know, |
| 1 | | No response |
| 100 % | | |

EXERCISE 331

(17: 9-51)

In the section of the electric circuit shown below, the voltmeter registers 100 volts and the ammeter registers 25 amperes. If the connecting wires and the ammeter have negligible resistance, the resistance of resistor R is




Age 17

| | | |
|---|---|---|
| 14 % | o | 2 ohm, |
| 25 | • | 4 ohms, |
| 5 | o | 25 ohms, |
| 3 | o | 100 ohms, |
| 18 | o | 2,500 ohms, |
| 33 | o | I don't know, |
| 0 | | No response |
| 100 % | | |

EXERCISE 332

(17: 9-57) (analogue Exercise 432)

Scientists can determine the age of heritage rocks and their fossils by measuring

Age 17

| | | |
|---|---|---|
| 7 % | o | their specific gravities, |
| 16 | o | their crystalline structure, |
| 23 | o | the rate at which they have eroded, |
| 28 | o | the ratio of radio-K to phosphorus in them, |
| 23 | • | the amounts of rare-Ca and lead they contain, |
| 23 | o | I don't know, |
| 0 | | No response |
| 100 % | | |

EXERCISE 333

(17: 9-58)

Experiments in which subatomic particles were shot at metal foil showed that atomic nuclei

Age 17

| | | |
|---|---|---|
| 7 % | o | contain counterclockwise, |
| 11 | o | are electrically neutral, |
| 19 | • | are much denser than the rest of the atom, |
| 23 | o | vibrate to and fro in simple harmonic motion, |
| 7 | o | are nearly as large as the atoms that contain them, |
| 34 | o | I don't know, |
| 0 | | No response |
| 99 % | | |

EXERCISE 334

(17: 9-61)

Which of these is synthesized in the mitochondria, then taken broken down in the cytosol and endoplasmic reticulum, with a resulting release of energy?

Age 17

| | | |
|---|---|---|
| 17 % | • | ATP |
| 19 | o | DNA |
| 23 | o | RNA |
| 8 | o | Cytosine |
| 3 | o | Golgi body |
| 30 | o | I don't know, |
| 0 | | No response |
| 100 % | | |

EXERCISE 135

(17: S-61 Overlaps Exercise 134)

Which of these has been used to obtain accurate estimates of the age of the oldest known rock strata?

| Age 17 | | |
|---|---|---|
| 25 % | O | Radiocarbon dating |
| 9 | ● | Uranium-lead dating |
| 2 | O | Potassium-argon dating |
| 11 | O | Estimation of sedimentation rates |
| 38 | O | Correlation of age of fossils contained in the strata |
| 15 | O | I don't know. |
| 0 | | No response |
| 100 % | | |

EXERCISE 136

(17: S-13)

In the equation below, which of the following elements are oxidized?

$SnS + 4ONO_3 \rightarrow S + SnO_2 + 4NO_2 + 2H_2O$

| Age 17 | | |
|---|---|---|
| 44 % | ● | Tin and sulfur |
| 10 | O | Tin and nitrogen |
| 11 | O | Sulfur and oxygen |
| 13 | O | oxygen and hydrogen |
| 13 | O | Nitrogen and oxygen |
| 41 | O | I don't know. |
| 0 | | No response |
| 84 % | | |

EXERCISE 137

(17: S-15)

Metal cans for holding foodstuffs are chiefly made of

| Age 17 | | |
|---|---|---|
| 2 % | O | copper. |
| 5 | ● | iron. |
| 2 | O | nickel. |
| 84 | O | tin. |
| 2 | O | I don't know. |
| 1 | | No response |
| 100% | | |

EXERCISE 138

(17: S-7)

A horizontal wire extends in the north-south direction. When a compass is placed directly beneath the wire, the compass needle turns and points east. It would be most reasonable to infer that

| Age 17 | | |
|---|---|---|
| 23 | ● | electrons are flowing south in the wire. |
| 6 | O | electrons are flowing east in the wire. |
| 30 | O | the wire is magnetized. |
| 1 | O | the wire is positively charged. |
| 17 | O | the wire is negatively charged. |
| 24 | O | I don't know. |
| 1 | | No response |
| 99 % | | |

## OBJECTIVE II: Possess the Abilities and Skills Needed to Engage in the Processes of Science

EXERCISE 139

(17: 15 = 8760)

A car stops at a traffic light and the engine stops running. The engine will not start again. Suggest three reasons why it will not start again.

| Age 17 | |
|---|---|
| Number of acceptable responses | |
| one 45 % | 1. |
| 2 22 | 2. |
| 3 18 | |
| 4 or 15 | |
| 100 % | 3. |

A response was scored acceptable if two or three reasons were given.

Only the first three correct items given by the examinee are to be considered.

Acceptable response is given to mean of those up to a total of 3:

1. No gas
2. Battery faulty
3. Starter motor faulty
4. Engine overheated, cylinderhead flooded
5. Sparkplugs faulty
6. Break in an electrical circuit
7. Fuel line blocked
8. Idle setting improper
9. Clutch not depressed
10. Engine cold
11. Vapor lock
12. Key stuck in ignition switch
13. Points faulty
14. Engine wet
15. Carburetor flooded
16. Distributor faulty
17. Choke stuck
18. Condenser faulty
19. Engine overheat flooded

Unacceptable reasons for problem:

1. Original reasons for stopping persists
2. Car in such condition that it won't start
3. Transmission won't go into first gear
4. some part of engine has failed
5. Incompetent driver
6. Lucky car
7. Car has stalled
8. Engine has burned out
9. Engine dead
10. Engine won't turn over
11. Not engine
12. Engine blow up
13. Car needs tuneup

EXERCISE 1c:

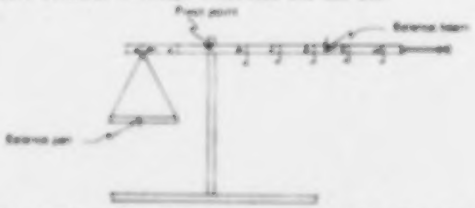
(17: 1-1)

In each of five experiments, two objects were weighed four times each. Which experiment gives the strongest evidence that object I weighs more than object II?

| Age 17 | | | Object I | Object II |
|---|---|---|---|---|
| 61 | E | Experiment A | 90 lbs. | 77 lbs. |
| | | | 91 lbs. | 69 lbs. |
| | | | 80 lbs. | 71 lbs. |
| | | | 82 lbs. | 75 lbs. |
| 4 | C | Experiment B | 69 lbs. | 81 lbs. |
| | | | 71 lbs. | 82 lbs. |
| | | | 70 lbs. | 80 lbs. |
| | | | 75 lbs. | 80 lbs. |
| 1 | A | Experiment C | 76 lbs. | 80 lbs. |
| | | | 75 lbs. | 75 lbs. |
| | | | 77 lbs. | 73 lbs. |
| | | | 80 lbs. | 72 lbs. |
| 5 | B | Experiment D | 84 lbs. | 75 lbs. |
| | | | 75 lbs. | 75 lbs. |
| | | | 73 lbs. | 73 lbs. |
| | | | 70 lbs. | 80 lbs. |
| 7 | D | Experiment E | 80 lbs. | 77 lbs. |
| | | | 78 lbs. | 76 lbs. |
| | | | 76 lbs. | 75 lbs. |
| | | | 77 lbs. | 79 lbs. |
| 5 | - | I don't know. | | |
| 2 | | No response | | |
| 99 % | | | | |

EXERCISE 1d:

(17: 14-12x1)




The apparatus before you is the same as that shown in the picture. This balance is balanced when the balance beam is level as shown above. The number by each mark on the beam tells the number of inches that mark is from the pivot point.

1. Place one weight in the balance pan. How many inches from the pivot point is the mark on which you must hang one weight to get balance? ____ (6)

| Age 17 | | |
|---|---|---|
| 75 % | C | Correct |
| 21 | I | Incorrect |
| 3 | - | No response |
| 99 % | | |

The apparatus also included fiveweights, one to place in the balance pan, and another to use to achieve balance. The respondent was given 20 minutes to find the answer to this and other questions involving the use of the apparatus (see Exercise 1e).

EXERCISE 1e:

(17: 1-4)

In a particular region there are many rabbits that eat the grass. There are also many hawks that eat the rabbits. Last year a disease broke out among the rabbits and a great number of them died. Which of the following probably then occurred?

| Age 17 | | |
|---|---|---|
| 6 % | I | The grass died and the hawk population increased. |
| 2 | I | The grass died and the hawk population decreased. |
| 59 | C | The grass grew taller and the hawk population increased. |
| 4 | I | The grass grew taller and the hawk population decreased. |
| 27 | I | Neither the grass nor the hawks were affected by the death of the rabbits. |
| 2 | - | I don't know. |
| 1 | | No response |
| 101 % | | |

EXERCISE 1f:

(17: 2-7)

Which of the following is a heavy metal other than a part of an ignition spark plug?

| Age 17 | | |
|---|---|---|
| 5 % | I | Platinum is a metal. |
| 7 | I | Platinum is more dense than water. |
| 4 | I | Platinum is the most beautiful metal. |
| 12 | I | Wedding bands should be made of platinum. |
| 70 | C | Reasons account for the stability of the market of platinum stocks. |
| 12 | - | I don't know. |
| 1 | | No response |
| 110 % | | |

EXERCISE 1g:

(17: 2e-12x1)

The apparatus before you is a pendulum. You have a watch in front also.

1. How long does it take for the weight at the end of the string to swing back and forth one time? ____ Seconds (No answer between 11 and 13 seconds and between 17 and 19 seconds.)

| Age 17 | | |
|---|---|---|
| 70 % | C | Correct |
| 21 | I | Incorrect |
| 9 | - | No response |
| 100 % | | |

EXERCISE 1h:

(17: 3-6)

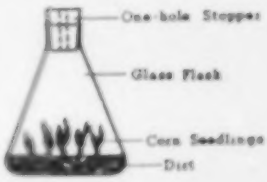
A student made the following statement. "Some vaccines strike at the blood that I are best might have come taken part of a Cancerous's body."
Which of the following is the best appraisal of the student's statement? This statement

| Age 17 | | |
|---|---|---|
| 6 % | I | contradicts the law of conservation of matter. |
| 7 | I | is contradicted because Hamburgers cooked at 1000 F. |
| 61 | C | could be true because drinks are rarely consumed or destroyed. |
| 16 | I | could be true only if the blood was given to cell carcinogens Cancerous tissues. |
| 5 | I | could not possibly be true because Hamburgers were actually fat wheat or a plant. |
| 15 | - | I don't know. |
| 2 | | No response |
| 96 % | | |

EXERCISE 14:

(17: 11-15)

Corn is planted in a flask as shown below. The flask is weighed each day for three weeks. The flask shows a daily weight loss. Which of the following is the best explanation of this loss of weight?




Age 17

17 a. A. The original water evaporates within the first day.

12 B. Carbon dioxide is lighter in weight than ordinary air.

8 C. Seed material is changed to leaves and roots that weigh less.

24 **D.** The seedlings use starch in the seeds and give off gases that escape.

26 E. The air enters through the stopper and replaces the moist air in the flask.

23 F. I don't know.

0 No response

---

90 b

EXERCISE 15:

(17: 14-15a)

The apparatus below you, is the same as that shown in the picture. This balance is balanced when the balance beam is level as shown above. The balance is then used on the Moon (with the number 10 inches from each end of the beam) the number 10 inches from each end of the beam will

The apparatus also included 11-gram 3-centigrams, a centimeter ruler, and a block of wood 11 by 7 by 2 centimeters. Measurements were given in metrics to answer numerical relational questions (a,b,c) and Exercises (d,e). The following question was preceded by cutouts which required them to make measurements which would enable them in answering (f).

a. What is the density of the wood block: It is _____ grams per cubic centimeter. (Any answer between .36 and .54 was scored correct.)

Age 17

| | |
|---|---|
| 12 A. | (Correct) |
| 61 | Two-to-one |
| 27 | No response |

---

100 b

EXERCISE 16:

(17: 16-17)

Which is which of the following is most useful in scientific research?

Age 17

| | |
|---|---|
| 0 A. | Memory |
| 2 B. | Logic |
| 1 C. | Applauding |
| 96 **D.** | Experimenting |
| 1 E. | Memorizing principles |
| 1 F. | I don't know. |
| 0 | No response |

---

101 b

EXERCISE 17:

(17: 8-11)

Researcher scientists carefully measure any quantity many times, they report that:

Age 17

| | |
|---|---|
| 10 A. | All of the measurements will be exactly the same. |
| 2 B. | Only two of the measurements will be exactly the same. |
| 7 C. | All but one of the measurements will be exactly the same. |
| 71 **D.** | Most of the measurements will be close but not exactly the same. |
| 5 E. | I don't know. |
| 0 | No response |

---

95 b

## Objective III: Understand the Investigative Nature of Science

EXERCISE 151

(17: 2-51)

Boyle's law, Charles' law, and Graham's law dealing with the behavior of gases can all be generalized in terms of which of the following?

| Age 17 | | |
|---|---|---|
| 8 % | O | Quantum theory |
| 4 | O | Recapitulation theory |
| 5 | O | Bohr theory of the atom |
| 29 | ● | Kinetic-molecular theory |
| 7 | O | Theory of natural selection |
| 47 | O | I don't know. |
| 0 | | No response |
| 100 % | | |

## OBJECTIVE IV: Have Attitudes about and Appreciation of Scientists, Science, and the Consequences of Science That Stem from Adequate Understandings

EXERCISE 152

(17: 11-41)

Most scientists

| Age 17 | | |
|---|---|---|
| 84 % | ● | want to know more about the world. |
| 3 | O | plan experiments as hastily as possible. |
| 4 | O | believe that some things happen without causes. |
| 3 | O | prefer lines and dividers to telescopes and microscopes. |
| 7 | O | use facts gathered by their own experiments and observations and pay no attention to results of others. |
| 4 | O | I don't know. |
| 0 | | No response |
| 100 % | | |

EXERCISE 153

(17: 6-47)

Which [illegible] are afraid of scientists to some [illegible] in every field of research.

| Age 17 | | |
|---|---|---|
| 17 % | O | I believe this statement. |
| 76 | ● | I don't believe this statement. |
| 7 | O | I don't know. |
| 0 | | No response |
| 100 % | | |

EXERCISE 154

(17: 13-45) [illegible]

[illegible] about a chemical [illegible] between [illegible] with a stimulating [illegible], do you watch it?

| Age 17 | | |
|---|---|---|
| 17 % | ● | Often |
| 24 | O | Sometimes |
| 59 | O | Never |
| 0 | O | I don't know. |
| 0 | | No response |
| 100 % | | |

## OBJECTIVE I: Know the Fundamental Facts and Principles of Science

EXERCISE A-2

(Adults 3-4)

The sex of a human baby is determined by which of the following?

| Adult | | |
|---|---|---|
| 2.0 | 0 | The length of the pregnancy |
| 3 | 0 | The mother's diet during pregnancy |
| 3 | 0 | The thoughts and wishes of the mother |
| 91 | • | Certain chromosomes in the fertilized egg |
| 1 | 0 | The kinds of activities in which the mother participates during pregnancy |
| 4 | 0 | I don't know. |
| 1 | | No response |
| 99% | | |

EXERCISE #17

(Adult: 9-17)

Which of the following organs in vertebrate produces sperm?

| Adult | | |
|---|---|---|
| [illegible] | o | Adrenal glands |
| 2 | o | Kidneys |
| [illegible] | o | Liver |
| 4 | o | Pancreas |
| 61 | • | Testes |
| 19 | o | I don't know. |
| 2 | | No response |
| 100% | | |

EXERCISE #18

(Adult: 1-13) (similar to Question 121)

The purpose of a fuse in an electric circuit is

| Adult | | |
|---|---|---|
| 1 | o | to raise the temperature of the wires in the circuit. |
| 1 | o | to increase the voltage across the circuit. |
| 2 | o | to increase the current in the circuit. |
| 1 | o | to decrease the electrical resistance. |
| 61 | • | to make the circuit safer. |
| 14 | o | I don't know. |
| - | | No response |
| 100% | | |

EXERCISE #19

(Adult: 3-12) (overlaps Exercise 178)

The idea of natural selection is usually associated with the theory of evolution proposed by ____.

| Adult | | |
|---|---|---|
| 61% | • | Charles Darwin. |
| 2 | o | Edward Jenner. |
| 1 | o | Jean Lamarck. |
| 0 | o | James Parkes. |
| 1 | o | Jonas Salk. |
| 34 | o | I don't know. |
| 1 | | No response |
| 100% | | |

EXERCISE #20

(Adult: 4-12) (overlaps Exercise 179)

An electric current in a copper wire involves mainly the movement of

| Adult | | |
|---|---|---|
| 1 | o | copper atoms. |
| 4 | o | copper molecules. |
| 61 | • | electrons. |
| 1 | o | neutrons. |
| 1 | o | protons. |
| 34 | o | I don't know. |
| 1 | | No response |
| 100% | | |

EXERCISE #21

(Adult: 9-17) (overlaps Exercise 177) (similar to Question 117)

Plants usually develop from

| Adult | | |
|---|---|---|
| 11 | o | leaves. |
| 61 | • | seeds. |
| 21 | o | petals. |
| 0 | o | roots. |
| 4 | o | stems. |
| 11 | o | I don't know. |
| 1 | | No response |
| 100% | | |

EXERCISE #22

(Adult: 3-12)

In organ transplant surgery, (eye, kidney, heart, liver, the separation of the transplanted organ by the firmness of the connective sheath be LIKELY likely to occur if the tissue were

| Adult | | |
|---|---|---|
| 61% | • | an chemical body. |
| 2 | o | the nature of the recipient. |
| 0 | o | all cells with cytoplasm be tissue groups. |
| 1 | o | a system not alive to cause that tissue rejects. |
| 34 | o | a biological body with the same tissue groups. |
| 11 | o | I don't know. |
| 1 | | No response |
| 100% | | |

EXERCISE #23

(Adult: 9-17) (overlaps Exercise 177)

Most of the commercial energy of the world is derived in a way is not used to make the iron but in manufacturing cars.

| Adult | | |
|---|---|---|
| 14% | o | atomic energy. |
| 61 | • | coal. |
| 1 | o | light. |
| 8 | o | magnetism. |
| 4 | o | steam. |
| 11 | o | I don't know. |
| 1 | | No response |
| 100% | | |

EXERCISE #24

(Adult: 9-12)

Most of the work required each year by the schools for the science comes from

| Adult | | |
|---|---|---|
| 61 | o | the air. |
| 1 | o | experimental labs. |
| 4 | o | medical industries. |
| 11 | • | research in schools. |
| 2 | o | the health fairs on the school site. |
| 21 | o | I don't know. |
| 1 | | No response |
| 100% | | |

EXERCISE 415

(Adult: 1-16) (overlaps Exercise 320)

A motor boat can travel 5 miles per hour on a still lake. If this boat travels downstream on a river that is flowing 5 miles per hour, how long will it take the boat to reach a bridge that is 10 miles downstream?

| Adult | | |
|---|---|---|
| 11 % | o | 15 min. |
| 11 | o | 30 min. |
| 5 | o | 45 min. |
| 56 | ● | 60 min. |
| 3 | o | 75 min. |
| 14 | o | I don't know. |
| 1 | | No response |
| 101 % | | |

EXERCISE 416

(Adult: 7-22) (overlaps Exercise 110)

On the average, in human females, the egg is released how many days after menstruation begins?

| Adult | | |
|---|---|---|
| 12 % | o | 2 days |
| 12 | o | 9 days |
| 55 | ● | 14 days |
| 4 | o | 20 days |
| 5 | o | 24 days |
| 11 | o | I don't know. |
| 1 | | No response |
| 100 % | | |

EXERCISE 417

(Adult: 1-7) (overlaps Exercise 106)

All of the following help to increase the total amount of food available to the human race EXCEPT

| Adult | | |
|---|---|---|
| 2 % | o | irrigating crops. |
| 12 | o | developing hybrids. |
| 2 | o | improving fertilizers. |
| 55 | ● | outlawing the use of insecticides. |
| 17 | o | controlling the growth of undesirable plants. |
| 10 | o | I don't know. |
| 1 | | No response |
| 99 % | | |

EXERCISE 418

(Adult: 4-20) (overlaps Exercise 119)

A 5-pound rock is dropped from a cliff 500 feet high. The longer the rock falls, the greater is its

| Adult | | |
|---|---|---|
| 18 % | o | acceleration. |
| 12 | o | potential energy. |
| 51 | ● | speed. |
| 7 | o | total energy. |
| 3 | o | volume. |
| 8 | o | I don't know. |
| 1 | | No response |
| 100% | | |

EXERCISE 419

(Adult: 9-20) (overlaps Exercise 211)

Which of the following is true of hot water as compared with cold water?

| Adult | | |
|---|---|---|
| 6 % | o | It is denser. |
| 2 | o | It is easier to see through. |
| 49 | ● | Its molecules are moving faster. |
| 4 | o | It has more free oxygen dissolved in it. |
| 1 | o | It has more free hydrogen dissolved in it. |
| 32 | o | I don't know. |
| 1 | | No response |
| 99 % | | |

EXERCISE 420

(Adult: 1-17) (overlaps Exercise 325)

What is the function of the placenta in a pregnant human female?

| Adult | | |
|---|---|---|
| 1 % | o | To push the baby out at birth |
| 5 | o | To keep the baby warm and moist |
| 45 | ● | To carry nourishment to the baby |
| 16 | o | To cushion the baby against shocks |
| 4 | o | To keep the baby's body temperature constant. |
| 27 | o | I don't know. |
| 1 | | No response |
| 101 % | | |

EXERCISE 421

(Adult: 1-15) (overlaps Exercise 227)

If a person who is a light eater has a tendency to be overweight, it is most likely due to

| Adult | | |
|---|---|---|
| 1 % | o | too much exercise. |
| 3 | o | a carefully balanced diet. |
| 22 | o | a tendency toward nervousness. |
| 4 | o | an excessive dosage of vitamins. |
| 45 | ● | highly efficient utilization of food by the body. |
| 24 | o | I don't know. |
| 2 | | No response |
| 99 % | | |

EXERCISE 422

(Adult: 2-23) (overlaps Exercise 221)

Most caves are formed by the action of underground water on

| Adult | | |
|---|---|---|
| 11 % | o | granite. |
| 43 | ● | limestone. |
| 1 | o | quartz. |
| 16 | o | sandstone. |
| 6 | o | shale. |
| 27 | o | I don't know. |
| 1 | | No response |
| 100 % | | |

EXERCISE 423

(Adult: 2-16)

The system of classifying plants and animals that is most commonly used in the biological sciences is based primarily on

| Adult | | |
|---|---|---|
| 8 % | O | food habits. |
| 15 | O | function. |
| 18 | O | geographical location. |
| 2 | O | size. |
| 42 | ● | structure. |
| 14 | O | I don't know. |
| 2 | | No response |
| 101 % | | |

EXERCISE 424

(Adult: 1-16)

Bacteria play a key role in all of the following EXCEPT

| Adult | | |
|---|---|---|
| 4 % | O | fermentation. |
| 40 | ● | photosynthesis. |
| 4 | O | causing disease. |
| 24 | O | nitrogen-fixation. |
| 3 | O | the decay of dead plants and animals. |
| 24 | O | I don't know. |
| 1 | | No response |
| 100 % | | |

EXERCISE 425

(Adult: 6-11) (overlaps Exercise 228)

A fossil of an ocean fish was found in a rock outcrop on a mountain. This probably means that

| Adult | | |
|---|---|---|
| 4 % | O | fish once lived on the mountain. |
| 1 | O | the relative humidity was once very high. |
| 19 | ● | the mountain was raised up after the fish died. |
| 4 | O | fish used to be amphibians like toads and frogs. |
| 41 | O | the fossil fish was probably carried to the mountain by a great flood. |
| 17 | O | I don't know. |
| 1 | | No response |
| 100 % | | |

EXERCISE 426

(Adult: 10-18) (overlaps Exercise 311)

The solid, liquid, and gaseous states of water differ in which of the following ways?

| Adult | | |
|---|---|---|
| 1 % | O | The number of protons per molecule |
| 1 | O | The number of electrons per molecule |
| 3 | O | The net charge on the individual molecules |
| 2 | O | The number of neutrons per individual molecule |
| 37 | ● | The average speed with which the molecules are moving |
| 53 | O | I don't know. |
| 2 | | No response |
| 99 % | | |

EXERCISE 427

(Adult: 7-11) (overlaps Exercise 227)

In mammals, which of the following is the center of memory and intelligence?

| Adult | | |
|---|---|---|
| 27 % | O | Cerebellum |
| 6 | ● | Cerebrum |
| 4 | O | Medulla |
| 4 | O | Optic nerve |
| 3 | O | Spinal cord |
| 54 | O | I don't know. |
| 2 | | No response |
| 100 % | | |

EXERCISE 428

(Adult: 4-10)

A man whose blood type is OA marries a woman whose blood type is OB. Their offspring could NOT have which of the following blood types?

| Adult | | |
|---|---|---|
| 31 % | ● | AA |
| 3 | O | AB |
| 1 | O | OA |
| 3 | O | OB |
| 12 | O | OO |
| 50 | O | I don't know. |
| 1 | | No response |
| 99 % | | |

EXERCISE 429

(Adult: 7-14)

The table in which all of the chemical elements are arranged to show many relationships among them is called the

| Adult | | |
|---|---|---|
| 9 % | O | activity table. |
| 26 | ● | periodic table. |
| 6 | O | table of acid strengths. |
| 4 | O | table of electronegatives. |
| 9 | O | table of oxidation potentials. |
| 45 | O | I don't know. |
| 1 | | No response |
| 100 % | | |

EXERCISE 430

(Adult: 6-19) (similar to Exercise 329)

Two light waves are traveling in a vacuum. The wave with the higher frequency will have the

| Adult | | |
|---|---|---|
| 2 % | O | lower speed. |
| 15 | O | higher speed. |
| 13 | O | longer wavelength. |
| 72 | ● | shorter wavelength. |
| 4 | O | more nearly horizontal direction. |
| 42 | O | I don't know. |
| 1 | | No response |
| 99 % | | |

EXERCISE 431

(Adult: 5-20) (overlaps Exercise 328)

If the cells referred to were all in the same organism, in which of the following is the amount of DNA present stated correctly?

| Adult | | |
|---|---|---|
| 21 % | ● | It would be identical in mature egg and sperm cells. |
| 1 | O | It would be identical in sperm cells and liver cells. |
| 6 | O | It would be identical in a mature egg cell and a brain cell. |
| 1 | O | It would be half as much in a thyroid cell as in a liver cell. |
| 2 | O | It would be half as much in the fertilized egg as in a thyroid gland cell. |
| 67 | O | I don't know. |
| 1 | | No response |
| 99 % | | |

EXERCISE 432

(Adult: 10-14)

The atomic weight of titanium is 48. This means that the average mass of titanium atoms is approximately

| Adult | | |
|---|---|---|
| 2 % | O | 1/48 gram. |
| 1 | O | 1 gram. |
| 4 | O | 48 grams. |
| 16 | ● | 4 times the mass of the atoms of a certain carbon isotope with atomic mass 12. |
| 5 | O | 48 times the mass of the atoms of a certain carbon isotope with atomic mass 12. |
| 71 | O | I don't know. |
| 1 | | No response |
| 100 % | | |

EXERCISE 433

(Adult: 1-14) (overlaps Exercise 332)

Scientists can determine the age of certain rocks and their fossils by measuring

| Adult | | |
|---|---|---|
| 4 % | O | their specific gravities. |
| 22 | O | their crystalline structure. |
| 17 | O | the rate at which they have eroded. |
| 10 | O | the ratio of calcium to phosphorus in them. |
| 15 | ● | the amounts of uranium and lead they contain. |
| 32 | O | I don't know. |
| 0 | | No response |
| 100% | | |

EXERCISE 434

(Adult: 8-18) (overlaps Exercise 335)

Which of these has been used to obtain accurate estimates of the age of the oldest known rock strata?

| Adult | | |
|---|---|---|
| 22 % | O | Radiocarbon dating |
| 2 | ● | Uranium-lead dating |
| 3 | O | Potassium-argon dating |
| 5 | O | Estimation of sedimentation rates |
| 22 | O | Correlation of age of fossils contained in the strata |
| 43 | O | I don't know. |
| 1 | | No response |
| 98 % | | |

## OBJECTIVE II: Possess the Abilities and Skills Needed to Engage in the Processes of Science

EXERCISE 435

(Adult: 7-12) (overlaps Exercise 152)

Why do very few people get smallpox in the United States today?

| Adult | | |
|---|---|---|
| 1 % | O | The weather conditions have changed. |
| 91 | ● | Most people get smallpox vaccinations. |
| 2 | O | People move more often than they used to. |
| 0 | O | People drink more milk today than ever before. |
| 1 | O | All the germs that cause smallpox have been killed. |
| 3 | O | I don't know. |
| 1 | | No response |
| 99 % | | |

EXERCISE 436

(Adult: 7-19) (overlaps Exercise 210)

A man notices that the paint on one side of his house is not lasting as well as the paint on the other sides. Which of the following is the most likely cause?

| Adult | | |
|---|---|---|
| 1 % | O | Termites |
| 2 | O | Insect bites |
| 94 | ● | Wind or sun |
| 1 | O | Fallout from atom bombs |
| 1 | O | Toxic gases from industrial use |
| 1 | O | I don't know. |
| 1 | | No response |
| 99 % | | |

EXERCISE 67

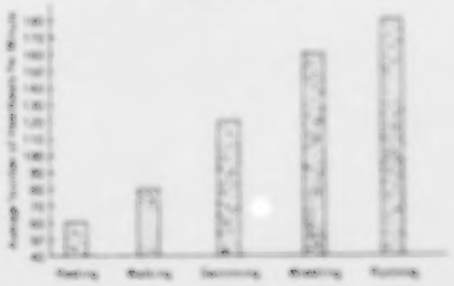
(Adult: 6-12)

According to the graph below, what is the average number of heartbeats per minute for a person swimming?

Adult

| | | |
|---|---|---|
| 1 | A | 60 |
| 2 | B | 90 |
| 99 | C | 120 |
| 3 | D | 150 |
| 4 | E | 180 |
| 5 | F | I don't know. |
| 6 | | No response |

AVERAGE NUMBER OF HEARTBEATS PER MINUTE IN DIFFERENT ACTIVITIES




EXERCISE 68

(Adult: 13-17)

Answer the questions about the picture.

1. Check one weight in the balance box. How many ounces does the green glass in the back of which you have just one weight?

Adult

| | |
|---|---|
| 1 | Ounces |
| 2 | Ounces |
| 3 | No response |

EXERCISE 69

(Adult: 2-7) Correlation questions 2-7 and 10-12

In each of five experiments, two objects were weighed four times each. Which experiment gives the strongest evidence that object A weighs more than object B?

Adult

| | | | Object A | Object B |
|---|---|---|---|---|
| 4-11 | ● | Experiment 1 | 8oz 10oz, | 9oz 10oz, |
| | | | 10oz 10oz, | 10oz 10oz, |
| | | | 9oz 10oz, | 9oz 10oz, |
| | | | 10oz 10oz | 9oz 10oz |
| 7 | 2 | Experiment 2 | 9oz 11oz | 9oz 9oz, |
| | | | 11oz 11oz, | 9oz 10oz, |
| | | | 10oz 11oz, | 9oz 10oz, |
| | | | 9oz 11oz | 9oz 10oz |
| 3 | 3 | Experiment 3 | 9oz 10oz, | 9oz 10oz, |
| | | | 9oz 10oz, | 9oz 10oz, |
| | | | 9oz 10oz, | 9oz 10oz, |
| | | | 9oz 10oz | 9oz 10oz |
| 1 | 4 | Experiment 4 | 9oz 10oz, | 9oz 10oz, |
| | | | 9oz 10oz, | 9oz 10oz, |
| | | | 9oz 10oz, | 9oz 10oz, |
| | | | 9oz 10oz | 9oz 10oz |
| 4 | 5 | Experiment 5 | 9oz 10oz, | 9oz 10oz, |
| | | | 9oz 10oz, | 9oz 10oz, |
| | | | 9oz 10oz, | 9oz 10oz, |
| | | | 9oz 10oz | 9oz 10oz |
| 12 | 6 | I don't know. | | |
| 1 | | No response | | |

EXERCISE 70

(Adult: 7-17) Correlation Exercise 10-1

In a particular country there are only two cities and the people. There are also only twelve food and the capitals. Each year a standard family eat meals for exactly and a great number of food crops. Which of the following problems does correlation?

Adult

| | | |
|---|---|---|
| 2-1 | A | The crops that eat the most potatoes increase. |
| 1 | B | The crops that eat the most potatoes increase. |
| 12 | ● | The crops that thrive and the most [illegible] increase. |
| 4 | D | The crops that suffer and the most [illegible] increase. |
| 11 | E | Workers who grain eat the least, also increase by the most in the economy. |
| 99 | F | I don't know. |
| 3 | | No response |

EXERCISE 43

(Adult: 10-21c1) (overlaps exercises 211 and 344)

The apparatus before you is a pendulum. You have a watch or clock also.

1. How long does it take for the weight in the pan on the end of the string to swing back and forth ten times? _____ seconds (An answer between 11 and 19 seconds was scored correct.)

| Adult | |
|---|---|
| 49 % | Correct |
| 37 | Incorrect |
| 12 | No response |
| 100 % | |

EXERCISE 44

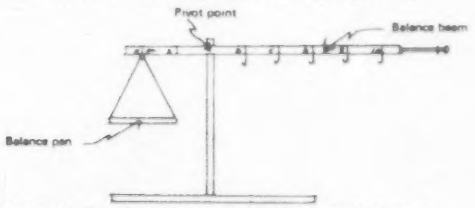
(Adult: 8-15) (similar to Exercise 345)

A student made the following statement, "Some carbon atoms in the bread that I ate last night might have once been part of a dinosaur's body."
Which of the following is the best appraisal of the student's statement? This statement

| Adult | | |
|---|---|---|
| 3 % | O | contradicts the law of conservation of matter. |
| 5 | O | is ridiculous because dinosaurs lived so long ago. |
| 25 | ● | could be true because atoms are rarely created or destroyed. |
| 7 | O | could not possibly be true because dinosaurs were animals but wheat is a plant. |
| 33 | O | could be true only if the bread was grown in soil containing dinosaur fossils. |
| 25 | O | I don't know. |
| 1 | | No response |
| 99 % | | |

EXERCISE 445

(Adult: 10-21a5) (overlaps exercises 240 and 348)




The apparatus before you is the same as that shown in the picture. This balance is balanced when the balance beam is level as shown above. The number by each mark on the beam tells the number of inches that mark is from the pivot point.

(The apparatus also included 10-gram fishweights, a centimeter ruler, and a block of wood 10 x 3 x 2 centimeters. Respondents were given 20 minutes to answer several related questions (e.g., see Exercise 438). The following question was preceded by others which required them to make measurements which would assist them in answering it.)

5. What is the density of the wood block? It is _____ grams per cubic centimeter. (An answer between .38 and .64 was scored correct.)

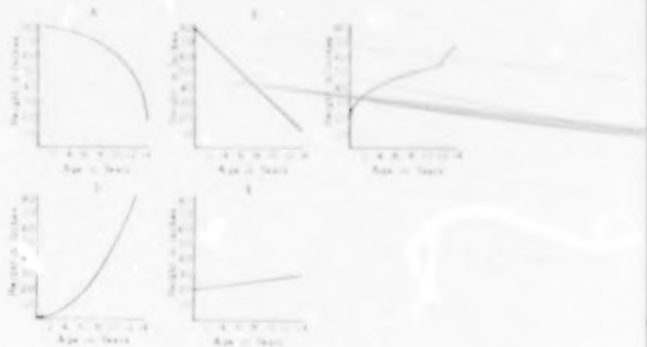
| Adult | |
|---|---|
| 12 % | Correct |
| 29 | Incorrect |
| 59 | No response |
| 100 % | |

EXERCISE 44

(Adult: 4-8) (similar to Exercise 239)

Which of the following graphs could show the average height in inches of a group of children growing at a normal rate plotted against their age in years?

| Adult | | |
|---|---|---|
| 6 % | O | A |
| 9 | O | B |
| 39 | ● | C |
| 18 | O | D |
| 9 | O | E |
| 16 | O | I don't know. |
| 1 | | No response |
| 100 % | | |




EXERCISE 444

(Adult: 4-14) (overlaps Exercise 346)

A particular cell is shaped like a cube. If all its linear dimensions were doubled, its volume would increase

| Adult | | |
|---|---|---|
| 4 % | O | 3 times. |
| 18 | O | 4 times. |
| 9 | O | 6 times. |
| 25 | ● | 8 times. |
| 16 | O | 16 times. |
| 28 | O | I don't know. |
| 1 | | No response |
| 101 % | | |

## Objective III: Understand the Investigative Nature of Science

[illegible]

[illegible]

## Objective IV: Have Attitudes about and Appreciation of Scientists, Science, and the Consequences of Science That Stem from Adequate Understandings

[illegible]

[illegible]